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Development and Application of a Risk Assessment Method for Radioactive Waste Management
Volume IV: AMRAW Computer Code. User's Manual

New Mexico Univ, Albuquerque. Bureau of Engineering Research

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16. ABSTRACT

A Radioactive Waste Management Systems Model, developed and implemented by The University of New Mexico under contract with the U.S. EPA, is presented. The systems model and associated computer code called AMRAW (Assessment Method for Radioactive Waste), has two parts. The first part, AMRAW-A, consists of the Source Term (radioactive inventory versus time), the Release Model, and the Environmental Model. The Release Model considers various geologic and man-caused events which are potential mechanisms for release of radioactive material from a repository or other location of emplacement. The environmental model describes the transport to and accumulation at various receptors in the biosphere, the transfer to man via various pathways, and the resulting radiation does. The systems model can be run in either of two modes determined by the manner in which postulated release events are assumed to occur. Release events can either be treated as discrete events occurring at specified times, or as probabilistic events distributed over time. The second part of the systems model, AMRAW-B, the Economic Model calculates health effects corresponding to the various organ dose rates from AMRAW-A, collects these health effects in terms of economic costs and attributes these costs to radionuclides, decay groups, and elements initially in the waste inventory. The implementation of AMRAW for terminal storage in a bedded salt reference repository is described and the application to a reference repository in a shale formation is discussed. Application to the repository operations phase and to the analysis of disposal of nonradioactive hazardous materials is also discussed.

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Nuclear Fuel Reprocessing	Assessment Methodology	1810
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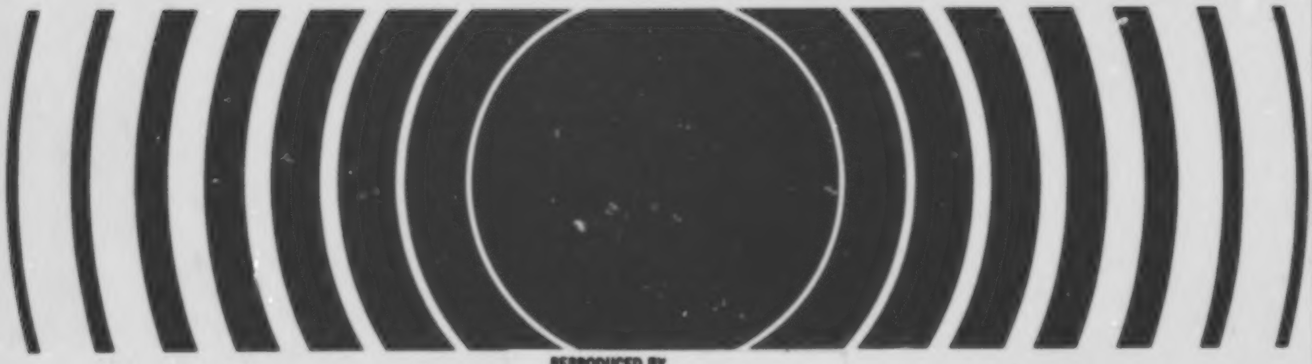

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DEVELOPMENT AND APPLICATION OF A RISK ASSESSMENT METHOD FOR RADIOACTIVE WASTE MANAGEMENT

Final Contract Report
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Volume IV: AMRAW Computer Code Users' Manual

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July 1978

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FOREWORD

The EPA Office of Radiation Programs carries out a national program to evaluate human exposures to radioactivity, and to promote the development of controls to protect the environment and public health from such radioactivity. An important part of this program consists of the development of environmental protection criteria and standards for radioactive waste management and disposal.

To sustain this effort, studies have been supported by EPA to develop methods to evaluate the environmental adequacy of proposed waste management alternatives, and this report describes one of the first attempts to develop a comprehensive assessment model. It has been funded at a very modest level. Much interest has been expressed in this work, and through publication, EPA is making it available to those involved with the development and use of models as decision-making tools.

In order for models to be useful as tools for decision-making concerning radioactive waste management alternatives, their capabilities and limitations must be fully understood. It should be noted that assessment models in themselves will not identify optimum waste management choices. However, they can be used to compare well defined alternatives. One of the necessary steps in any model development and validation process is the comparison of results with results obtained from the application of alternate models to test cases. It is hoped that as other comprehensive assessment models become available, comparison studies can be performed.

The methodology described herein has been applied, for model illustration purposes, to a reference repository in a bedded salt formation located in the southwestern United States. Any results published in this report should not be interpreted as implying conclusions concerning the suitability of the reference site or any site-specific method/repository combination for the preparation and disposal of radioactive waste.

Comments on this analysis as well as any new information would be welcomed; they may be sent to the Director, Technology Assessment Division (AW-459) Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, D.C. 20460.

W. D. Rowe, Ph.D.
Deputy Assistant Administrator
for Radiation Programs (AW-459)

ABSTRACT

A Radioactive Waste Management Systems Model, developed and implemented by The University of New Mexico under contract with the U. S. Environmental Protection Agency, is presented. The systems model and associated computer code called AMRAW (Assessment Method for Radioactive Waste), has two parts. The first part, AMRAW-A, consists of the Source Term (radioactive inventory versus time), the Release Model, and the Environmental Model. The Release Model considers various geologic and man-caused events which are potential mechanisms for release of radioactive material beyond the immediate environs of a repository or other location; the risk analysis mode uses events distributed probabilistically over time, and the consequence analysis mode uses discrete events occurring at specified times. The Environmental Model includes: 1) the transport to and accumulations at various receptors in the biosphere, 2) pathways from these environmental concentrations, and 3) resulting radiation dose to man.

The second part of the systems model, AMRAW-B, is the Economic Model which calculates health effects corresponding to the various organ dose rates from AMRAW-A, collects these health effects in terms of economic costs and attributes these costs to radionuclides, decay groups, and elements initially in the waste inventory. Implementation, with calculated results, of AMRAW for Terminal Storage in a Bedded Salt Reference Repository are presented. Preliminary demonstrations for the repository operations phase of waste management and terminal storage in a shale formation are described; possible applications to other radioactive and nonradioactive hazardous materials are discussed. AMRAW uniquely links all steps together in a continuous calculation sequence.

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Assistance in planning the AMRAW users' guide was by K. E. Patterson and C. C. Herrmann. AMRAW-B information used for preparation of the guide was furnished by S. Ben-David and D. S. Brookshire; auxiliary program material was prepared by H. S. Ng. Others at UNM who participated in the project, including AMRAW programming, and other persons making direct contributions are named in the Acknowledgements section of Volume I.

DEVELOPMENT AND APPLICATION OF A RISK ASSESSMENT METHOD FOR RADIOACTIVE WASTE MANAGEMENT

VOLUME LISTING

VOLUME I	GENERIC DESCRIPTION OF AMRAW-A MODEL
VOLUME II	IMPLEMENTATION FOR TERMINAL STORAGE IN REFERENCE REPOSITORY AND OTHER APPLICATIONS
VOLUME III	ECONOMIC ANALYSIS; DESCRIPTION AND IMPLEMENTATION OF AMRAW-B MODEL
VOLUME IV	AMRAW COMPUTER CODE USERS' MANUAL

VOLUME IV

TABLE OF CONTENTS

PAGE

Foreward.. iii
Abstract.. v
Acknowledgements.. vi
List of Volumes... vii
List of Figures... x
List of Tables.. x
List of Abbreviations, Symbols
  and Nomenclature.. xii

CHAPTER 1. INTRODUCTION.................................. 1

PART 1: AMRAW-A USERS' GUIDE

CHAPTER 2. SUMMARY 5
  A. PROGRAM SUMMARY 5
  B. PURPOSE 6
  C. METHOD 7
CHAPTER 3. INPUT/OUTPUT DESCRIPTION...................... 11
  A. CARD INPUT SPECIFICATIONS........................ 12
  B. OUTPUT DESCRIPTION 23
CHAPTER 4. PROGRAM OPTIONS 27
CHAPTER 5. ERROR MESSAGES 31

APPENDICES FOR PART 1

  A. BACKGROUND MATERIAL 33
  B. SAMPLE RUN REQUEST 34
  C. SAMPLE CODING FORM 35
  D. JOB PROCESSING INSTRUCTIONS 41
  E. OPERATING DECK SETUP 42
  F. SAMPLE INPUT AND OUTPUT 43

TABLE OF CONTENTS (CONTINUED)

PAGE

G. PROGRAMMER'S NOTES 67
H. AMRAW-A LISTING 70
I. FLOWCHART 89
J. AUXILIARY PROGRAMS 91

PART 2: AMRAW-B USERS' GUIDE

CHAPTER 6. SUMMARY 109
A. PROGRAM SUMMARY 109
B. PURPOSE 110
C. METHOD 111
CHAPTER 7. INPUT/OUTPUT DESCRIPTION...................... 113
A. CARD INPUT SPECIFICATIONS 115
B. OUTPUT DESCRIPTION 118
CHAPTER 8. PROGRAM OPTIONS 121
CHAPTER 9. ERROR MESSAGES 123

APPENDICES FOR PART 2

K. BACKGROUND MATERIAL 125
L. SAMPLE RUN REQUEST 127
M. SAMPLE CODING FORM 129
N. JOB PROCESSING INSTRUCTIONS 131
O. OPERATING DECK SETUP 133
P. SAMPLE INPUT AND OUTPUT 135
Q. PROGRAMMER'S NOTES 151
R. AMRAW-B LISTING 155
S. FLOWCHART 163
T. AUXILIARY PROGRAM 165

VOLUME IV

LIST OF FIGURES

FIGURE PAGE

1-1 Radioactive waste management systems model.............. 2

1-2 One branch of systems model............................ 3

I-1 AMRAW-A simplified flowchart........................... 90

J-1 SENDY simplified flowchart............................. 97

J-2 SENDY operating deck setup............................. 98

S-1 AMRAW-B simplified flowchart........................... 164

LIST OF TABLES

TABLE PAGE

3-1 Directory of AMRAW-A Output Tables..................... 24

4-1 Calculation and Output Options Controlled by NPRINT.... 28

C-1 Sample Coding Form for One Nuclide, One Zone, and One Organ... 36

F-1 Input Data... 45

F-2 Output Data.. 49

H-1 Main Program... 71

H-2 Subprograms.. 84

J-1 POLYEPA Program 93

J-2 SENDY Program 101

7-1 Arrangement of AMRAW-A Dose Rate Output; Local Dose Rate by Zone and Nonspecific Dose Rate 114

7-2 Directory of AMRAW-B Output Tables..................... 119

M-1 Sample Coding Form with First Cards of Each Type Illustrated 130

LIST OF TABLES (CONTINUED)

PAGE

P-1 Data File, AMB 136

P-2 Data File, AM1E 137

P-3 Data File, ECON48.. 138

P-4 Sample of AMRAW-A Output 139

P-5 Sample of AMRAW-A Output 140

P-6 Output Summary of Selected Input 142

P-7 AMRAW-B Output Table 1-1; Zonal and Total Damages for High Population Projection 143

P-8 AMRAW-B Output Table 1-2; Zonal and Total Damages for Low Population Projection 144

P-9 AMRAW-B Output Tables 2-9 and 2-14; Annual Damage Rates by Nuclide 145

P-10 AMRAW-B Output Table 3; Discounted Present Values 146

P-11 AMRAW-B Output Table 4-1; High Population Scenario, Number of Deaths per Time Interval 147

P-12 AMRAW-B Output Table 4-2; Low Population Scenario, Number of Deaths per Time Interval 148

P-13 AMRAW-B Output Table 5-1; Total Undiscounted Damages for Each Zone for Each Time Interval, High Population 149

P-14 AMRAW-B Output Table 5-2; Total Undiscounted Damages for Each Zone for Each Time Interval, Low Population 150

R-1 AMRAW-B Listing 156

T-1 COMPRESS Listing 166

VOLUME IV

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

PART 1

A

AA1(JF, J)	Fraction of inventory transferred to receptor JF if a release via cutset J (i.e., JJ) occurs
ADJ	Fraction of inventory transferred from one environmental receptor pool to another pool per unit time; obtained from ADJ1 and ADJ2
ADJ1(JF,JFA,IZ)	Maximum fraction of a quantity dispersed to receptor JFA in Zone IZ which can be transferred to receptor JF in the same zone; paired with ADJ2 for inter-receptor adjustments over time following an initial dispersion.
ADJ2(JF,JFA,IZ)	Transfer rate constant associated with ADJ1, y^{-1}
AL	Axial dispersivity coefficient, m
AMRAW	(Assessment Method for Radioactive Waste) Assessment Model and associated computer code
AMRAW-A	That portion of AMRAW which includes Source Terms, Release Model, and Environmental Model
AMRAW-B	The economic part of AMRAW
AREAW (IZ)	Surface area of water by zone, cm^2
AREAG	Zone land surface area, cm^2, over which nuclide is deposited
AT	Transverse dispersivity coefficient, m
A1	Transfer coefficient giving fraction of inventory transferred from inventory to receptor JF and due to release mechanism under consideration; obtained from subroutine FAULT and is equal to AA1(JF,J) except for leaching
A2	Time transfer coefficient accounting for radioactive and environmental decay occurring between release and population dose times; calculated within subroutine TRINP with help of function CRATIO for ground water transport calculations

A2MIN	Truncation value (to 0.0) for A2 (accounts for decay and transport processes)

B

BIOFAC (K, JF, I)	Concentration or integrated concentration in food or drink per unit receptor concentration, by subpath I, up to NS = NSP(JF); units are $(\mu Ci\text{-}y/g)/(\mu Ci/cm^2)$ for terrestrial food, $(\mu Ci/g)/(\mu Ci/cm^3)$ for aquatic food, and dimensionless for drinking water
BULKD	Bulk solid density of aquifer, g/cm^3

C

C	Transfer coefficient which transforms environmental concentration in a receptor to corresponding dose commitment rate to a specified organ; calculated in subroutine TRMAN
CINV	Total number of canisters in inventory
CFAI	Number of canisters exposed to leach incident
CHECK	Flag for errors in data field; alphanumeric identification of checkpoint number (ICHEK)
COMPRESS	An auxiliary program for preparing an AMRAW-B input file from AMRAW-A output
CP(JF,J,K)	Function parameter: size of step function, slope of ramp function, exponential constant or set = 1.0 for delta function; K is component factor
CRATIO	Subroutine in AMRAW-A for ground water transport calculations
CRMIN	Cutoff value for CRATIO (ground water concentration)

D

DC1(K)	Effective diffusivity for nuclide K leaching, cm^2/d
DELTE	Time interval over which environmental decay constant is applied; also, time increment for which inter-receptor transfer is calculated
DELTL	Time increment during release to environment period

DECFAC	Effective radioactive decay factor between two times
DEP	Deposition concentration for water and ground surface (Ci/cm^2) due to air deposition
DEPGND	Total deposition on land surface of zone
DEPWTR	Total deposition on water surface of zone
DFMIN	Cutoff value for DECFAC (decay factor)
DISPN (JF, IZ)	Area or volume over which, or in which, a release is dispersed in each receptor JF in each zone IZ, cm^2 or cm^3
DOSFAC(K,JF,MODE,IH)	Dose commitment conversion factor for each organ IH of NIHT total; each card has conversion factors for specified nuclide and receptor/exposure mode combination, $(mrem/y)/(\mu Ci/cm^3)$, $(mrem)/(\mu Ci/cm^2)$ or $mrem/\mu Ci$, as appropriate
DRC (K)	Dissolution rate constant for nuclide K leaching, d^{-1}

E

EDC(K, I, IZ)	Environmental decay constants for nuclides K, receptor JF (represented here by I) and Zones IZ; data sequence on cards is EDC by zone to MZ zones for first nuclide, repeated in turn for each subsequent nuclide to NK nuclides; if ISECT = 4, this group of cards is repeated in turn for JF = 2 and JF = 3
ELEM (ID)	Symbol for each of ND chemical elements

F

FS	Exposed area of solidified waste specimen (canister as fractured), cm^2
FAULT	Subroutine in AMRAW-A which handles the Release Model and provides transfer coefficients used to accumulate releases to four preliminary input receptors
FUNCTION CRATIO	Determines concentration ratio in ground water at discharge point compared to release point; this ground water transport function is called by SUBROUTINE TRINP
FUNCTION RLEACH	Calculates amount of nuclide leached into the ground water preliminary environmental input receptor; the function is called by SUBROUTINE FAULT when a leach incident is involved

G

GNDDIS	Ground dispersion, related to ground water velocity and aquifer dimensions
GNDEP	Non-accumulating matrix which retains integrated deposition for current time increment for use in calculating transfer to terrestrial food products

H

HT	Height of aquifer, m

I

ICHCK	Flag for errors in data file--gives check point number
IFDIVW	Ground water time increment control; IFDIVW = 0 avoids subdivision of time increments and IFDIVW > 0 causes sub-division branch in subroutine TRINP to be executed
IFLAGE(JF,MODE,I)	Flag used in Environment-to-Man Pathways model designating whether output is accumulated as "local dose" (IFLAGE = 1) or "nonspecific dose" (IFLAGE = 2).
IFLAG(JF,J,K)	Probability function designation: 0 Constant 1 Step function 2 Ramp function 3 Exponential function 4 Delta function K is component factor of cutset J releasing to receptor JF
IE	Output medium for error and data check point messages
IN	Input medium, normally card reader
IP	Output medium (line printer or tape)
ISTART	Starting zone number
ISTOP	Ending zone number
ISECT	Control flag for EDC data; ISECT = 1: internal EDC default values used for JF = 2 & 3 (= 2.30×10^{-5}), type 36 cards ommited; ISECT = 2: EDC default values used for JF = 3, type 36 cards read for JF = 2;

	ISECT = 3: EDC default values used for JF = 2, type 36 cards read for JF = 3; ISECT = 4: type 36 cards read for JF = 2, followed by cards for JF = 3
ITE	TIME subscript used for designation of time increment, Δt, within environmental time period of interest
ITR	TIME subscript used for designation of time increments, Δt, within radionuclide release time period
ITRS	TIME subscript for release start time; appears for end of time increment when release calculations start
ITRE	TIME subscript for release end time; appears for end of time increment when release calculations cease (end)
ITSUMY	TIME subscript for first table in Section 6 of output
ITSUMJ	Increment on time subscript for successive tables
IW	Model branch or waste management phase (IW = 1 is residuals treatment; = 2 is transportation; = 3 is repository operations, and = 4 is terminal storage)
IZ	Subscript--geographic zone designation
IZONE(I)	Identification number for each zone to be tabulated up to IZONM zones; note, IZONE(10) designates nonspecific dose category
IZONM	Number of zones to be tabulated

J

JF	Subscript--Environmental Receptor designation (JF = 1 is air; = 2 is land surface; = 3 is surface water; = 4 is ground water)
JFA	Environmental Receptor from which interreceptor transfer is made to receptor JF
JJ(JF, I)	Cutset sequential identification number for cutset I, up to NJ

K

K	Subscript--radionuclide designation, or in probability calculations K designates component factor of cutset J releasing to receptor JF

KSUB	The nuclide K level for subtotal line in tables (as for subtotal of fission products followed by actinides)

L

LPRINT	Counter

M

MAN1L(ITE,IH)	Average annual local dose to individual by nuclide, organ, and zone, mrem/y
MAN1W(ITE,IH)	Average annual nonspecific dose to population by nuclide and organ, man-rems/y
MAN2L(ITE,IH,IZ)	Average annual local dose to individual, total all nuclides, total all receptors, by organ and zone, mrem/y
MAN2LF(ITE,IH,IZ,JF)	Average annual local dose to individual, total all nuclides, by receptor, organ, and zones, mrem/y
MAN2N(ITE,IH)	Average annual nonspecific dose to individual, total all nuclides, total all receptors, by organ, man-rem/y
MAN2NF(ITE,IH,JF)	Average annual nonspecific dose to individual, total all nuclides, for receptor JF = 1 to 4, by organ, man-rem/y
MC	Number of columns in output tables (FOR POLYEPA)
MODE	A major grouping of environmental pathways under a receptor; in general, MODE = 1 is external exposure and MODE = 2 is internal
MS	Number of time intervals corresponding to the repository operations phase (for POLYEPA)
MT	Number of time reporting points (each "time increment" is between adjacent time reporting points)
MTADJ	Number of interpolated output time points (for POLYEPA)
MW	Maximum number of operation modes
MZ	Number of geographic zones calculated
M1	Counter
M10	Counter

N

NCASE	Identification number of case or cases submitted
ND	Number of chemical elements in inventory
NIHT	Number of body organs being calculated
NJ (JF)	Number of cutsets (release scenarios) for each receptor JF
NJJ(JF, I)	Number of component factors for cutset I
NK	Number of isotopes in inventory
NPRINT	Output table specification
NSP (JF)	Number of subpaths for each receptor JF; the value of NSP for each JF applies to both modes 1 and 2 for each receptor
NUCNAM (K)	Symbol name for nuclide K, double precision, up to 8 characters each

O

ORGNAM (I)	Names of organs (body sites) for which dose rates are calculated, up to I = NIHT, double precision, up to 8 characters each

P

POLYDATA	Data file for assembling POLYEPA input data
POLYEPA	An auxiliary program for preparing nuclide inventory data matrix by curve-fitting source data to prescribed times specified in AMRAW input
POLYDD	POLYEPA output data storage file
PORE	Aquifer porosity (as decimal)
PROBB(JF,J,K)	Initial probability of occurrence of component factor, y^{-1}; K is component factor

R

RELOUT	Release fraction by each cut set for each nuclide, to each Environmental Input Receptor

REMOV(JFA,IZ)	Used in accounting nuclide reduction in receptor JFA due to interreceptor transfer to receptor JF
RKD(K)	Distribution coefficient K_d, by nuclide K, cm^3/g
RKDMAX	Cutoff value for RKD (distribution coefficient K_d) above which ground water transport calculations may be bypassed
RLEACH	Subprogram in FAULT which handles leaching into ground water
R1J(JF, ITR)	Release increment to each Preliminary Environment Input Receptor from all release events by nuclide, for different times, Curies
R1JMIN	Truncation value (to 0.0) for R1J (Curies released to a given receptor)
R2(JF,ITE,IZ)	Adjusted concentration per release increment by receptor
R2CON	Intermediate unit conversion value of R2 used in accumulating R2TOT
R2MIN	Truncation value (to 0.0) for R2 (component of environmental concentration R2TOT)
R2TOT	Accumulated net total concentration in μCi per cm^2 or cm^3 by zone and Environment Input Receptor, for different times

S

SENDY	An auxiliary program for comparing results in tables from AMRAW run with corresponding tables from another run
SPACT (K)	Specific activity of nuclide K, Ci/g
SUBROUTINE FAULT	Determines release probability transfer coefficient; also, by use of time dependent component factors, the subroutine can modify the nuclide inventory at risk
SUBROUTINE TRINP	Determines transport-to-environment transfer coefficient, accounting for decay and other processes such as delay in ground water transport
SUBROUTINE TRMAN	Determines environment-to-man transfer coefficient for dose to man via all pathways from environmental concentrations

T

TFUEL	Total inventory in repository, metric tons
TIME (I)	The time in years at each of MT time reporting points
TIMEAD(I)	Time in years at each of MTADJ output time points (for POLYEPA)
TITLE	Title of run or case (1-10)
TP(JF,J,K)	Time at which functional change in probability commences, y; K is component factor

V

VOLINT(JF,MODE,I,IZ)	Consumption, exposure or food production rate, as appropriate, y/y, cm^3/y, or g/y
VS	Volume of solidified waste specimen (canister), cm^3
VX	Ground water seepage velocity, m/d

X

X(K, IT)	Mass of nuclide K at TIME (IT), grams
XL(I)	Distances from repository to average discharge point in each zone for I = 1 to MZ zones; XL = 0.0 indicates to code that contaminated plume does not discharge in zone
XX (ID)	Total inventory of each element at end of repository operations, grams

Y

YW(I)	Effective width of plume (width for concentration 0.1% of center line value) in each zone (distance XL) where discharge occurs, for I = 1 to MZ zones, m; input as 0.0 for each zone where no discharge occurs (not used except in output display)
YY(I)	Distance from plume centerline where concentration equals average across effective width YW, in each zone (distance XL) where discharge occurs, for I = 1 to MZ zones; input as 0.0 for each zone where no discharge occurs (not used except in output display)

Z

ZAVG	Average quantity of nuclide in Curies during release time increment
ZONALO(JF,IZ)	Dispersion allocation factors by zone IZ for transport-to-environment receptor JF, Ci-y/cm^3-Ci for JF = 1, Ci/Ci for JF = 2, 3; for JF = 4, ZONALO = 1.0 designates effected ground water in zone; 0.0 designates none
ZONDEP (IZ)	Surface deposition factor by zone IZ, Ci/cm^2-Ci

PART 2

AMB	One of three AMRAW-B input files; provides economic model control and conversion data
AMRAW	(Assessment Method for Radioactive Waste) Assessment Model and associated computer code
AMRAW-A	That portion of AMRAW which includes Source Term, Release Model, and Environmental Model
AMRAW-B	The economic part of AMRAW
AM1E	One of three AMRAW-B input files; provides time values, nuclide names and masses at each time
COMPRESS	An auxiliary program for preparing an AMRAW-B input file from AMRAW-A input
DAMAGE	An intermediate calculated value, damage per person (or nonspecific category), $/y, during a given time increment, for a given zone and nuclide, summed for dose to all organs
DDP	Implied value of dose, $/man-rem
DLD	An output parameter for Table 4, denoting deaths per time interval
DPY	Incidence rate for health effects, cases per 10^6 man-rem (dose to organs)
DT	An output parameter for Table 1, denoting DTZ summed over all zones
DT9	An output parameter for Table 1, denoting DTZ summed over all zones and the nonspecific category

DTZ	An output parameter for Tables 1 and 2, denoting damage rate (given nuclide and time) by zone for Table 1, $/y, and various summations for Table 2. For the latter, subscripts 1 through 5 represent, respectively: local damage summed over zones for high population, local damage summed over zones for low population, nonspecific damage, total of local and nonspecific damage for high population, and total for low population
DYRH	An output parameter for Table 5, denoting discounted damages per time interval, $, for high population projection
DYRL	Same as DYRH except for low population projection
ECONxx	One of three AMRAW-B input files; provides restructured output matrix MAN1 of dose rates from AMRAW-A (xx is case no.)
IH	Organ identifier subscript
IKK	Subscript identity of each of K nuclides in group
IN	Number which specifies computer input medium
IP	Number which specifies computer output medium
IS	Number which specifies an input medium with large storage used for file ECONxx
IT	Time subscript used in matrices
ITB3	Number which specifies printing option for Table 2 (1 - requests printing; 0 - suppresses printing)
IZ	Subscript used for zone identification
K	Number of nuclides in group
MAN1	Refers to large dose rate output matrix from AMRAW-A
MAN1L	Average annual local dose to individual by nuclide, organ, and zone, mrem/y, comprising part of MAN1
MAN1N	Average annual nonspecific dose to population by nuclide and organ, man-rem/y, comprising part of MAN1
MZ	Number of geographic zones
NG	Number of nuclide decay groups
NIHT	Number of organs (body sites)
NK	Number of nuclides

NT	Number of times
NUCNAM, NUC2	Abbreviated nuclide name, e.g., AM 242M
POPH	Input high population projection by zone
POPL	Input low population projection by zone
PV2	An output parameter for Table 3, denoting disconnected present value of damages from a given nuclide over the full time range
REG	Name of zone
RATE	Discount rate expressed as decimal; input in file AMB
SPV	An output parameter for SS for all decay groups
SS	An output parameter for Table 3, denoting sum of PV2 for all nuclides in a given decay group, $; also, used for marginal damages for a given decay group, $/gm
TIME (I)	Time in years for each subscripted value of TIME
TTD	An output parameter for Table 4, denoting sum of DLD over all time increments
TUDH	An output parameter for Table 5, denoting sum of DYRH over all time increments
TUDL	An output parameter for Table 5, denoting sum of DYRL over all time increments
VOL	Cost of increased levels of risk; input in file AMB
X	Quantity of given nuclide in inventory at given time, gm

(former para 5)

CHAPTER 1

INTRODUCTION

The Radioactive Waste Management Systems Model (Fig. 1-1) has several parallel paths, each representing a phase in the waste management sequence: residuals treatment (interim surface storage and solidification at a reprocessing plant site), waste transport, repository operations, and terminal storage. If other phases become applicable, such as interim surface storage away from a reprocessing plant site, interim storage as spent fuel, reprocessing of waste form, and other transportation steps, each of these simply becomes an additional parallel path in the model. One branch (parallel path) of the systems model is shown in greater detail in Fig. 1-2.

Implementation of the model is by the AMRAW computer code (Assessment Method for Radioactive Waste Management). The code runs calculations separately for each branch of the model. AMRAW is divided into two parts which are run separately: 1) AMRAW-A (see Figs. 1-1 and 1-2), described in Vols. I and II, begins with the inventory at risk and calculates population dose rates, and 2) AMRAW-B, described in Vol. III, uses the calculated population dose rates, applies incidence rates of health effects associated with radiation dose and calculates the economic costs of health effects in the population.

The model provides for technology assessment of radioactive waste management in two categories: 1) risk analysis, which considers the probabilities of occurrence of various radiation release scenarios and the consequence of such releases, and 2) consequence analysis, which considers only the consequences of the various low-probability potential release events assuming they do occur. The methodology permits evaluation of the various long-term waste disposal methods and management options, for protection of public health and safety and protection of resources.

A user's guide for AMRAW-A is presented in Part 1 and for AMRAW-B in Part 2 of this volume.

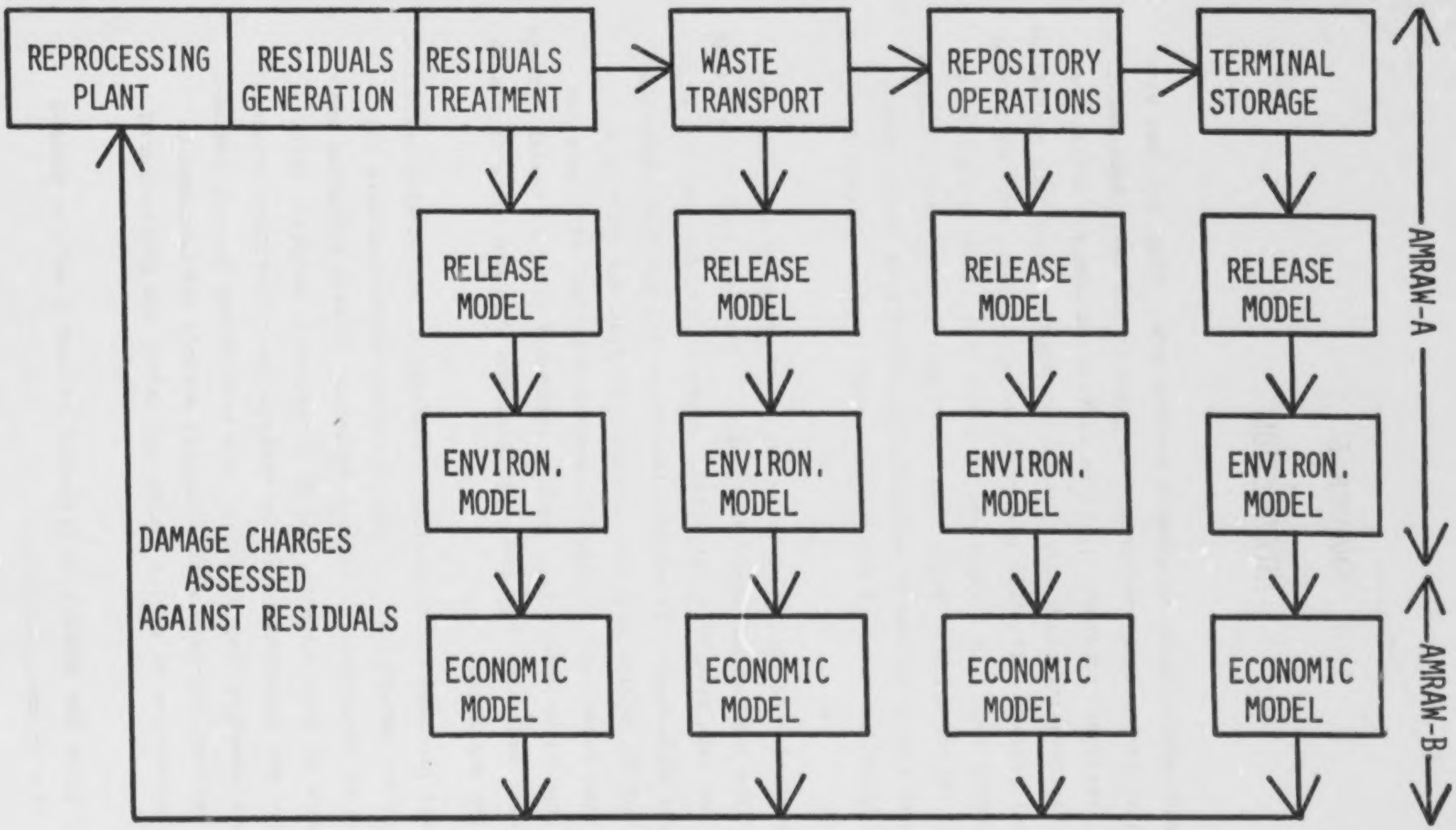
REPROCESSING PLANT
RESIDUALS GENERATION
RESIDUALS TREATMENT
WASTE TRANSPORT
REPOSITORY OPERATIONS
TERMINAL STORAGE
RELEASE MODEL
ENVIRON. MODEL
ECONOMIC MODEL
DAMAGE CHARGES ASSESSED AGAINST RESIDUALS
AMRAW-A
AMRAW-B

Figure 1-1. Radioactive waste management systems model.

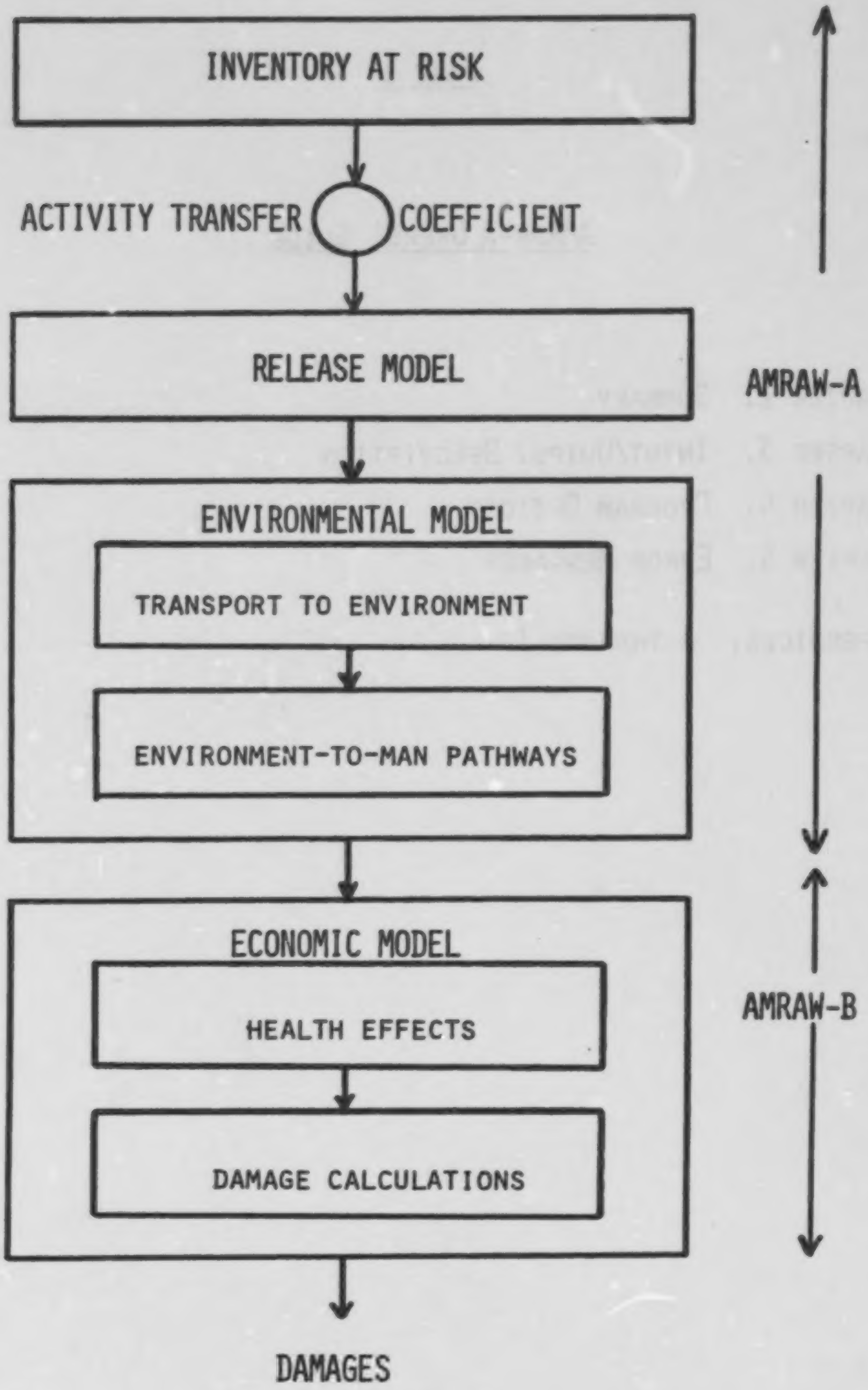
INVENTORY AT RISK
ACTIVITY TRANSFER
COEFFICIENT
RELEASE MODEL
AMRAW-A
ENVIRONMENTAL MODEL
TRANSPORT TO ENVIRONMENT
ENVIRONMENT-TO-MAN PATHWAYS
ECONOMIC MODEL
HEALTH EFFECTS
AMRAW-B
DAMAGE CALCULATIONS
DAMAGES

Figure 1-2. One branch of systems model.

Part 1

AMRAW-A Users' Guide

Chapter 2. Summary
Chapter 3. Input/Output Description
Chapter 4. Program Options
Chapter 5. Error Messages

Appendices: A through J

CHAPTER 2

SUMMARY

A. PROGRAM SUMMARY

Title: AMRAW-A; Assessment Method for Radioactive Waste (First Part).

Abstract: AMRAW performs a sequence of calculations for an inventory of radioactive wastes, evaluating release quantities, dispersion to the environment, and pathways for dose to man.

Effective Date: January, 1978.

Programmer: S. E. Logan

Computer: IBM 360/67

Language: Fortran IV

Core Memory Requirement: 256 k bytes

Execution Time (CP sec): < 1,300

Auxiliary Hardware Requirements: Disk, Tape, Line Printer

B. PURPOSE

AMRAW-A, the first part of the Radioactive Waste Management Systems Model, calculates population dose rates from postulated releases of radioactive material. Population dose rates are divided into local dose rates for populations within each of several geographic zones and nonspecific dose rates which are associated with largely exported agricultural products. Sub-models consider in series (see Fig. 1-2): the inventory at risk (Source Term), postulated release scenarios in the Release Model, dispersion from the locale of release to environmental receptors in each geographic zone (Transport to Environment) and the pathway analysis (Environment-to-Man Pathways).

C. METHOD

The AMRAW code is written in Fortran IV language. The AMRAW-A part of the AMRAW computer code may be run for one or more branches of the model, depending upon the number of sets of input data provided. The discussion which follows is based upon the terminal storage branch, in that the frame of reference refers to the inventory emplaced in a repository. However, the calculation flow of the model and code also applies to the other branches.

The code is structured with sequences of "receptors" separated by transfer coefficients. The receptors represent the progress of releases, environmental concentrations, concentrations in food and drink, radiation doses, health effects and associated economic damages. The transfer coefficients are evaluated in subroutines using externally-determined input data. The subroutines can be modified or replaced, providing a modular arrangement. Factors for dispersion, biological accumulation, dose, etc., used in the transfer coefficients, are evaluated externally by various existing transport and dose codes.

Each branch of the model (Fig. 1-2) is entered with the mass of each significant radionuclide in the inventory at risk. This is converted to Curies in the inventory by an activity transfer coefficient (specific activity). The Release Model evaluates the probability for release by each of numerous potential release mechanisms, and the fraction of the inventory released by each such occurrence, during each increment of time. AMRAW may be run for any of several release scenarios: 1) probabilistic distribution of events over time, 2) discrete event at specified time, 3) several events each at mean time of first occurrence, 4) dynamic repository simulation, or 5) combinations of these. Subroutine FAULT handles the Release Model and provides the transfer coefficients used to accumulate releases to four preliminary input receptors from all release events considered. This subroutine uses function RLEACH when an event involves leaching into ground water.

Releases as determined by the Release Model are not necessarily directly to the environment. This is particularly true for deep releases to ground water. The first portion of the Environmental Model is therefore the "Transport to Environment" section. This adjusts each release increment, obtaining the contribution-to-concentrations in environmental input receptors at various times following release. These receptors are: air, ground surface, surface water, and ground water. The adjustment provides for dispersion into each of the several geographical zones comprising the study region, and then accounts for dispersion areas or volumes in each zone. The adjustment also accounts for decay from the time of release to the time being evaluated, transfer between receptors (such as deposition from air onto ground), retardation in ground water flow, and other environmental removal or fixation processes. Subroutine TRINP handles transport from the preliminary input receptors, providing transfer coefficients which account for physical and environmental decay and ground water transport delays. This subroutine uses function CRATIO for the ground water transport calculations. Use of the transfer coefficients from TRINP by the main program leads to net environmental concentrations for input to pathway analysis.

The last portion of the Environmental Model covers the pathways from environmental input concentrations to radiation dose to the population, with dose rate calculations for several organs of concern. Subroutine TRMAN handles evaluation of transfer coefficients between environmental concentrations and population dose rates for the various pathways. Pathways include immersion in air, inhalation, ingestion of ground water and contaminated food and drink (from contaminated ground surface and surface water), submersion in water, and direct surface exposure.

The present dimensioning of AMRAW-A is as follows:

1) Radionuclides: 25.

2) Environmental receptors: 4, designated by programming as Air, Land Surface, Surface Water, and Ground Water.

3) Release Model events: 9 events or event combinations under each of the 4 environmental receptors. Each may be input with up to 9 component factors. Each of these factors may be flagged for type of function (constant, step, ramp, exponential, or delta) and specified by three appropriate function parameters.

4) Environmental pathways: 2 main pathways (modes) are programmed

for each environmental receptor. Dimensioning provides for up to 6 subpaths for each receptor (each mode under a given receptor is divided into the same number of subpaths).

5) Geographic zones: 8.

6) Human organs: 8. Typically, one of these is total body, but there is no restriction.

7) Time increments: 50.

With this dimensioning, the code runs with 256 k bytes of core storage, 10 cylinders (1459 k bytes) of disc storage, and requires 21 minutes of CPU time in the UNM IBM 360/67 computer. The range of subscripts for variables is specified by input data and may be any value within the above dimensioning with the exception of environmental receptors which are fixed within the code at four. Dimensioning may be increased if necessary, limited only by available core storage or other system requirements.

Large output matrices for local and nonspecific dose rates are written onto disc to conserve core space. Complete output is then written onto magnetic tape for retention but output may be diverted directly to printer by job control statements if preferred. Printed output is subsequently obtained from the tape as needed. If AMRAW-B is to be coupled to AMRAW-A for a combined run, AMRAW-B may access the disc for dose rate input data. The operation demonstrated at UNM is separate running of AMRAW-B. For this purpose, the dose rate portion of the AMRAW-A output is obtained from tape.

CHAPTER 3

INPUT/OUTPUT DESCRIPTION

Input for AMRAW-A is by an 80 column card data deck. There are 40 card types. As implemented at UNM, the input deck is read from two files in disk storage (file division made between card types 19 and 20), instead of from a card reader. No additional inputs are required. Card input is described in the following section.

Output is described in Section 3.B.

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A. CARD INPUT SPECIFICATIONS

1. Data Deck Setup. Descriptions and number required of each card type are given in section 2 which follows. The sequence of the data deck, beginning with the first or front card is listed below:

Card Type	Item
1	NCASE
2	TITLE
3	ND, NK, MT, IW, ITRS, ITRE, MZ, NIHT, NPRINT, IFDIVW
4	R1JMIN, A2MIN, R2MIN, RKDMAX, CRMIN, DFMIN
5	TIME
6	ELEM
7	TFUEL
8	XX
9	NUCNAM, X
10	CHECK, ICHCK
11	SPACT
12	DC1
13	DRC
14	ADJ1, ADJ2
15	DISPN
16	ZONALO
17	ZONDEP
18	AREAW
19	RKD
20	CHECK, ICHCK
21	NSP
22	VOLINT
23	BIOFAC
24	CHECK, ICHCK
25	ORGNAM
26	DOSFAC
27	CHECK, ICHCK
28	NJ
29	JJ, NJJ

(There are 4 sets of card types 28 - 31)

Card Type	Item
30	AA1
31	PROBB, IFLAG, TP, CP
32	IFLAGE
33	VX, PORE, AL, AT, HT, BULKD, FS, VS, XL, YW, YY, CINV, CFAI
34	CHECK, ICHCK
35	ISECT
36	EDC (omitted if ISECT = 1)
37	CHECK, ICHCK
38	IZONM
39	IZONE
40	ITSUMY, ITSUMJ, KSUB

2. Description of Card Input. There are 3 subscripts prominently involved with input data: K, JF, and IZ. Subscript K designates the radionuclide, presently dimensioned to handle up to 25 nuclides. Subscript JF designates the 4 environmental receptor (shortened to "receptor" in descriptions which follow): JF = 1 is air, JF = 2 is land surface, JF = 3 is surface water, and JF = 4 is ground water. Subscript IZ designates geographic zones in the study region, presently dimensioned to handle up to 8 zones. Other subscripts are identified below as they occur.

The largest matrices of data are for X (card type 9), BIOFAC (card type 23), and DOSFAC (card type 26). The Release Model input (card types 28 to 31) can be as large as 400 cards if the full dimensioned capability is used. If EDC (card type 36) is read in instead of using internal default values, it is also a large input matrix. Because of the large amount of input data required, there are 6 check points provided; if any check point test is not satisfied, an error statement is output which identifies the block of data in which there are extra or omitted cards, and the run is terminated.

A list of each card type in input sequence, the necessary card format in each instance, the number of each card type required (one card unless stated otherwise), the data items and their descriptions, plus other explanatory notes are presented below.

Card Type	Format and Item	Description
1.	FORMAT (I5)	
	NCASE	Number of cases submitted.
2.	FORMAT (10A8)	3 cards
	TITLE	Title of case, double precision, up to 80 characters per card.
3.	FORMAT (16I5)	
	ND	Number of chemical elements in inventory.
	NK	Number of isotopes in inventory.
	MT	Number of time reporting points (each "time increment" is between adjacent time reporting points).
	IW	Model branch or waste management phase (IW = 1 is residuals treatment; IW = 2 is transportation; IW = 3 is repository

Card Type	Format and Item	Description
		operations and IW = 4 is terminal storage).
	ITRS	TIME subscript for end of time increment when release calculations start.
	ITRE	TIME subscript for end of time increment when release calculations cease (end).
	NZ	Number of geographic zones calculated.
	NIHT	Number of body organs calculated.
	NPRINT	Output table specification (see Chap. 3).
	IFDIVW	Ground water time increment control; IFDIVW = 0 avoids subdivision of time increments and IFDIVW > 0 causes subdivision branch in subroutine TRINP to be executed.
4.	FORMAT (8E10.2)	This card specifies truncation or cutoff values to avoid overflow, underflow, or nonproductive calculations.
	R1JMIN	Truncation value (to 0.0) for R1J (Curies released to a given receptor).
	A2MIN	Truncation value (to 0.0) for A2 (accounts for decay and transport processes).
	R2MIN	Truncation value (to 0.0) for R2 (component of environmental concentration R2TOT).
	RKDMAX	Cutoff value for RKD (distribution coefficient K_d) above which ground water transport calculations may be bypassed.
	CRMIN	Cutoff value for CRATIO (ground water concentration).
	DFMIN	Cutoff value for DECFAC (decay factor).
5.	FORMAT (8E10.2)	1 card for each 8 time points.
	TIME (I)	The time in years at each of MT time reporting points.
6.	FORMAT (20A4)	1 card if ND ≤ 20.
	ELEM (ID)	Symbol for each of ND chemical elements.
7.	FORMAT (8E10.2)	
	TFUEL	Total inventory in repository, metric tons.
8.	FORMAT (8E10.2)	1 card for each 8 elements.
	XX (ID)	Total inventory of each element at end of repository operations, grams.
9.	FORMAT (A8, 2X, 7E10.2)	Minimum of 1 card for each of NK nuclides; add one card for each nuclide for each 7 time points beyond the first 7 points.

Card Type	Format and Item	Description
	NUCNAM (K)	Symbol name for nuclide K, double precision, up to 8 characters each.
	X(K, IT)	Mass of nuclide K at TIME (IT), grams.
	FORMAT (10X, 7E10.2)	Used for all cards after the first for each nuclide (bypasses rereading NUCNAM).
10.	FORMAT (19A4, I2)	This card provides a check field to provide error statement and terminate runs if incorrect number of cards read to this stage.
	CHECK	Alphanumeric identification of checkpoint no. 1, up to 76 columns.
	ICHCK	01 in columns 77 and 78.
11.	FORMAT (8E10.2)	1 card for each 8 nuclides.
	SPACT (K)	Specific activity of nuclide K, ci/g.
12.	FORMAT (8E10.2)	1 card for each 8 nuclides.
	DC1(K)	Effective diffusivity for nuclide K leaching, cm^2/d.
13.	FORMAT (8E10.2)	1 card for each 8 nuclides.
	DRC (K)	Dissolution rate constant for nuclide K leaching, d^{-1}.
14.	FORMAT (8E10.2)	4 cards for each zone (1 card for each of 4 receptors in each zone). These cards provide pairs of adjustment parameters for inter-receptor adjustments over time following an initial dispersion.
	ADJ1(JF,JFA,IZ)	Maximum fraction of a quantity dispersed to receptor JFA in zone IZ which can be transferred to receptor JF in the same zone.
	ADJ2(JF,JFA,IZ)	Transfer rate constant associated with ADJ1, y^{-1}.
	Read as:	$\Big(\Big(\Big(ADJ1(JF,JFA,IZ),\ ADJ2(JF,JFA,IZ),\ JFA = 1,\ 4\Big),\ JF = 1,\ 4\Big),\ IZ = 1,\ MZ\Big)$
15.	FORMAT (8E10.2)	4 cards (1 for each receptor)
	DISPN (JF, IZ)	Area or volume over which, or in which, a release is dispersed in each receptor JF in each zone IZ, cm^2 or cm^3.
	Read as:	$\Big(\Big(DISPN(JF,IZ),\ IZ = 1,\ MZ\Big),\ JF = 1,\ 4\Big)$
16.	FORMAT (8E10.2)	4 cards (1 for each environmental receptor).

Card Type	Format and Item	Description
	ZONALO (JF, IZ)	Dispersion allocation factors by zone IZ for transport-to-environment receptor JF, Ci^{-y}/cm^3-Ci for JF = 1, Ci/Ci for JF = 2, 3. For JF = 4, ZONALO = 1.0 designates effected ground water in zone; 0.0 designates none.

Read as: $\left(\left(\text{ZONALO(JF,IZ)}, \text{IZ} = 1, \text{MZ}\right), \text{JF} = 1, 4\right)$

Card Type	Format and Item	Description
17.	FORMAT (8E10.2) ZONDEP (IZ)	Surface deposition factor by zone IZ, Ci/cm^2-Ci.
18.	FORMAT (8E10.2) AREAW (IZ)	Surface area of water by zone, cm^2.

Note: Corresponding AREAG, land surface by zone, is set within code = DISPN (2, IZ).

Card Type	Format and Item	Description
19.	FORMAT (8E10.2) RKD(K)	1 card for each 8 of NK nuclides. Distribution coefficient K_d, by nuclide K, cm^3/g.
20.	FORMAT (19A4, I2)	This card provides the second data check point.
	CHECK	Alphanumeric identification of check point no. 2, up to 76 columns.
	ICHCK	02 in columns 77 and 78.

The following card types 21 to 23, and 25 and 26 provide data for the Environment-to-Man Pathways model (see Table 3-3 in Vol. I).

Card Type	Format and Item	Description
21.	FORMAT (16I5) NSP (JF)	Number of subpaths for each receptor JF. The value of NSP for each JF applies to both modes 1 and 2 for each receptor.
22.	FORMAT (8E10.2)	4 cards (1 for each receptor) for each zone.
	VOLINT(JF,MODE,I,IZ)	Consumption, exposure or food production rate, as appropriate, y/y, cm^3/y, or g/y.

Read as: $\left(\left(\text{VOLINT(JF,MODE,I,IZ)}, \text{I} = 1, \text{NS}\right), \text{MODE} = 1, 2\right)$,

where I is subpath under JF, up to NS = NSP(JF).

Card Type	Format and Item	Description
23.	FORMAT (8E10.2)	3 cards (1 each for receptors JF = 2, 3, 4) for each of NK nuclides.

Card Type	Format and Item	Description
	BIOFAC (K, JF, I)	Concentration or integrated concentration in food or drink per unit receptor concentration, by subpath I, up to NS = NSP(JF). Units are $(\mu\text{Ci-y/g})/(\mu\text{Ci/cm}^2)$ for terrestrial food, $(\mu\text{Ci/g})/(\mu\text{Ci/cm}^3)$ for aquatic food, and dimensionless for drinking water.
	Note: BIOFAC for JF = 1 (air) is set = 1.0 in code.	
24.	FORMAT (19A4, I2)	This card provides the third data check point.
	CHECK	Alphanumeric identification of check point point no. 3, up to 76 characters.
	ICHCK	03 in columns 77 and 78.
25.	FORMAT (10A8)	
	ORGNAM (I)	Names of organs (body sites) for which dose rates are calculated, up to I = NIHT, double precision, up to 8 characters each.
26.	FORMAT (8E10.2)	8 cards for each of NK nuclides (2 for each of 4 receptors JF; first of each pair for MODE 1 and second for MODE 2).
	DOSFAC(K,JF,MODE,IH)	Dose commitment conversion factor for each organ IH of NIHT total. Each card has conversion factors for specified nuclide and receptor/exposure mode combination, $(\text{mrem/y})/(\mu\text{Ci/cm}^3)$, $(\text{mrem}/(\mu\text{Ci/cm}^2)$, or $\text{mrem}/\mu\text{Ci}$, as appropriate.
27.	FORMAT (19A4, I2)	This card provides the fourth data check point.
	CHECK	Alphanumeric identification of check point no. 4, up to 76 characters.
	ICHCK	04 in columns 77 and 78.

The following card types 28 to 31 provide data for the Release Model scenarios (see Table 6-4, Vol. II) calculated by subroutine FAULT. As presently dimensioned, each of 4 receptors JF may have up to 9 cutsets (release scenarios) NJ, and each cutset may have up to 9 component factors NJJ. This portion of the data deck can have from 4 cards (trivial case with zero release scenarios for each receptor) to 400 cards, as follows:

4 sets of cards, 1 set for each receptor JF:
  Card type 28 1 card (if NJ = 0, subsequent cards for this JF are omitted).
  1 set of cards for each of NJ cutsets (9 maximum):

Card Type	Formula and Item	Description
	Card type 29 1 card Card type 30 1 card Card type 31 1 card for each of NJJ component factor (9 maximum).	
28.	FORMAT (16I5)	4 cards, sequenced as stated above.
	NJ(JF)	Number of cutsets (release scenarios) for each receptor JF.
29.	FORMAT (16I5)	Number of cards as stated above.
	JJ(JF, I)	Cutset sequential identification number for cutset I, up to NJ.
	NJJ(JF, I)	Number of component factors for cutset I.
30.	FORMAT (8E10.2)	Number of cards as stated above.
	AA1(JF, J)	Fraction of inventory tranferred to receptor JF if a release via cutset J (i.e., JJ) occurs.
31.	FORMAT (E10.2, I10, 2E10.2)	Number of cards as stated above. Subscripts on this card are: K designates component factor (not to be confused with nuclide K used elsewhere) of cutset J (i.e. JJ) releasing to receptor JF.
	PROBB(JF,J,K)	Initial probability of occurrence of component factor, y^{-1}.
	IFLAG(JF,J,K)	Probability function designation: 0 Constant 1 Step function 2 Ramp function 3 Exponential function 4 Delta function.
	TP(JF,J,K)	Time at which functional change in probability commences, y.
	CP(JF,J,K)	Function parameter: size of step function, slope of ramp function, exponential constant, or set = 1.0 for delta function.
	Note:	For the constant function, TP and CP may have any value (not used) but 0.0 is suggested to avoid confusion in output display.
32.	FORMAT (16I5)	4 cards (1 for each receptor)
	IFLAGE(JF,MODE,I)	Flag used in Environment-to-Man Pathways model designating whether output is accumulated as "local dose" (IFLAGE = 1) or "nonspecific dose" (IFLAGE = 2), (see Table 6-14, Vol. II). Values are sequenced on card for each of NSP subpaths under MODE = 1, followed by each of NSP subpaths under MODE = 2.

The following series of 2 to 5 cards of type 33 provide data for the leach subprogram RLEACH and the ground water transport subprogram CRATIO.

Card Type	Format and Item	Description
33.	FORMAT (8E10.2)	2 cards for 1 or 2 zones, 3 cards for 3 or 4 zones, 4 cards for 5 or 7 zones, and 5 cards for 8 zones.
	VX	Ground water seepage velocity, m/d.
	PORE	Aquifer porosity (as decimal).
	AL	Axial dispersivity coefficient, m.
	AT	Transverse dispersivity coefficient, m.
	HT	Height of aquifer, m.
	BULKD	Bulk solid density of aquifer, g/cm^3.
	FS	Exposed area of solidified waste specimen (canister as fractured), cm^2.
	VS	Volume of solidified waste specimen (canister), cm^3.
	XL(I)	Distances from repository to average discharge point in each zone for I = 1 to MZ zones. XL = 0.0 indicates to code that contaminated plume does not discharge in zone.
	YW(I)	Effective width of plume (width for concentration 0.1% of center line value) in each zone (distance XL) where discharge occurs, for I = 1 to MZ zones, m. Input as 0.0 for each zone where no discharge occurs (not used except in output display).
	YY(I)	Distance from plume centerline where concentration equals average across effective width YW, in each zone (distance XL) where discharge occurs, for I = 1 to MZ zones. Input as 0.0 for each zone where no discharge occurs (not used except in output display).
	CINV	Total number of canisters in inventory.
	CFAI	Number of canisters exposed to leach incident.
34.	FORMAT (19A4, I2)	This card provides the fifth data check point.
	CHECK	Alphanumeric identification of check point no. 5, up to 76 characters.
	ICHCK	05 in columns 77 and 78.

The following type 35 card controls data for the environmental decay constant EDC(K,JF,IZ), y^{-1}, where subscripts denote nuclide, receptor, and zone, respectively. EDC for JF = 1 & 4 is set by statements in the code: EDC(K, 1, IZ) = 50, providing for rapid deposition

Card Type	Format and Item	Description
		from air after dispersion, and EDC (K, 4, IZ) = 0.0, as EDC has no present application to ground water calculations.
35.	FORMAT (16I5)	
	ISECT	Control flag for EDC data. ISECT = 1: internal EDC default values used for JF = 2 & 3 (= 2.30 x 10^{-5}). Type 36 cards omitted. ISECT = 2: EDC default values used for JF = 3; type 36 cards read for JF = 2. ISECT = 3: EDC default values used for JF = 2; type 36 cards read for JF = 3. ISECT = 4: type 36 cards read for JF = 2, followed by cards for JF = 3.
36.	FORMAT (8E10.2)	0 cards if ISECT = 1; MZ x NK/8 cards if ISECT = 2 or 3; 2(MZ x NK)/8 cards if ISECT = 4.
	EDC(K, I, IZ)	Environmental decay constants for nuclides K, receptor JF (represented here by I) and zones IZ. Data sequence on cards is EDC by zone to MZ zones for first nuclide, repeated in turn for each subsequent nuclide to NK nuclides. If ISECT = 4, this group of cards is repeated in turn for JF = 2 and JF = 3.
37.	FORMAT (19A4, IZ)	This card provides the sixth (and last) data check point.
	CHECK	Alphanumeric identification of check point no. 6, up to 76 characters.
	ICHCK	06 in columns 77 and 78.

The following card types 38 to 40 control selection of output for dose summary tables in Section 6 of output. Each such table is for a specified time.

Card Type	Format and Item	Description
38.	FORMAT (16I5)	
	IZONM	Number of zones to be tabulated.
39.	FORMAT (16I5)	
	IZONE(I)	Identification number for each zone to be tabulated, up to IZONM zones. Note: IZONE(10) designates nonspecific dose category.
40.	FORMAT (16I5)	
	ITSUMY	Time subscript for first table.
	ITSUMJ	Increment on time subscript for successive tables.

Card Type	Format and Item	Description
	KSUB	The nuclide K level for subtotal line in tables (as for subtotal of fission products followed by actinides).

A sample coding form for 1 nuclide, 1 zone, and 1 organ is given in Appendix C. More complete sample input is given in Appendix F.

B. OUTPUT DESCRIPTION

AMRAW-A requires three output mediums: disk, tape file, and line printer.

1. Disk. Intermediate temporary storage of calculated values for each nuclide is on disk. The disk storage capacity required is up to 1459 k bytes of information. Information stored on disk is transferred to tape (or directly to line printer) at the end of each case.

2. Tape File. The tape file is used to store selected run output transferred from disk into several tabular configurations. The output stored on tape may subsequently be used in part as input to AMRAW-B (Economic Model), used as input to auxiliary codes for further analysis, or may be directed to a line printer for one or multiple printed copies. If preferred, and if further computer processing of output is not planned, output can be routed directly to the line printer instead of to tape.

3. Line Printer. The line printer must be capable of 132 characters per line. The preferred mode of operation is to direct output stored on the tape file to the line printer instead of routing output directly to line printer. In addition to the major output, error statements and data check point confirmations are output. Error and check point statements are routed to the output medium specified by the variable IE (see Chapter 4) and should always be set to the line printer.

4. Output Tables. Extensive output tabulations are produced by AMRAW-A, as directed by the output control parameter (see card type 3, and Chapter 4). These tables are divided into 6 sections, each set off by a divider page for clarity. Table 3-1 is a directory of output tables. The number of tables listed of each type is based upon 25 nuclides, 8 zones, and 8 organs, resulting in a total of 627 tables if all are requested by NPRINT. The number of tables is reduced appropriately for fewer nuclides, zones, or organs. Sample output is given in Appendix F.

Table 3-1. Directory of AMRAW-A Output Tables

Description	[a]Number of Table Combinations				Total
	Nuclides	Zones	Organs	Environ. Receptors	
SECTION 1. Data Input					
1. Output listing of AMRAW input.	(20 pages)				
SECTION 2. Release to Environment					
1. Release Fractions by Each Cutset, RELOUT	25				25
2. Release Increments to Preliminary Environmental Input Receptors, R1J, from All Release Events, Ci	25			(4 in each table)	25
3. Concentrations at Environment Input Receptor, R2TOT. Units: JF = 1 μCi-y/cm^3, JF = 2 μCi/cm^2, JF = 3 and 4 μCi/cm^3.	25	8			200
SECTION 3. Local Dose to Individual					
1. Average Annual Local Dose to Individual, MAN1L, mrem/y.	25	8	(8 in each table)		200
SECTION 4. Nonspecific Dose to Population					
1. Average Annual Nonspecific Dose to Population, MAN1N, manrem/y.	25		(8 in each table)		25

Table 3-1. Directory of AMRAW Output Tables (continued)

	Nuclides	Zones	Organs	Environ. Receptors	Total
SECTION 5. Total Dose by Receptors					
1. Average Annual Local Dose to Individual, MAN2LF for JF = 1 to 4, MAN2L for Total, mrem/y, Total for All Nuclides.		8	8	(4 in each table)	64
2. Average Annual Nonspecific Dose to Population, MAN2NF for JF = 1 to 4, MAN2N for Total, manrem/y, Total for All Nuclides.			8	(4 in each table)	8
SECTION 6. Dose Summary Tables					
1. Average Annual Local Dose to Individual, MAN1L, in Zone, mrem/y.	(25 in each table)	[b] up to 8	(8 in each table)	[c] 5	40
2. Average Annual Nonspecific Dose to Population, MAN1N, manrem/y.	(25 in each table)	[b] up to 8	(8 in each table)	[c] 5	40
Total Number of Tables					627

Note:

a. All output tables, except Section 6 are for 50 time steps, 0 to 10^6 years.

b. Individual zones may be specified.

c. Section 6 may call for a table for each of all times beginning with 100 y or skip some times; 5 tables result if call for every ninth time.

CHAPTER 4

PROGRAM OPTIONS

The first class of program options is concerned with design of the application. The number of nuclides, zones, organs, times, release scenarios, and environmental pathways may be varied within the range of dimensioning. The reader is referred to Vol. I for full discussion of these and other general input data options.

The input/output mediums are specified in statements in the main program which assign values for the variables IN, IE, and IP appropriate to the system being used (at UNM the values are 5, 6, and 2, respectively).

IN	specifies the input medium, normally the card reader
IE	specifies the output medium for error and data check point messages; this should always be set to the line printer
IP	specifies the output medium for the code; this is normally tape file but it may be set to the line printer if preferred.

Calculation and output options are controlled by NPRINT (see card type 3, Chapter 3). This control variable has 3 digits, described in Table 3-1. The complete calculation and output capability is executed if NPRINT = 500. Options range down to setting the first digit to zero (such as NPRINT = 000 or simply = 0) resulting in reading in and outputting all data (in the Section 1 explanatory tabular arrangement) but performing no calculations. The latter is useful during setting up and checking a large data file.

EDC (environmental decay constant) values are internally set for the JF = 1 and 4 receptors. An option is provided for the values for JF = 2 and 3 receptors, controlled by ISECT (see card type 35 in Chapter 3). If ISECT = 1, internal EDC default values are used for both receptors. If EDC data is available for specific nuclides, receptors and zones, this may be read in by setting ISECT = 2 to 4. If ISECT = 2, EDC is read in for JF = 2; if ISECT = 3, EDC is read in for JF = 3; if ISECT = 4, EDC is read in for JF = 2 and 3.

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Table 4-1. Calculation and Output Options Controlled by NPRINT

NPRINT = XYZ

Z controls organs calculated.

if Z = 0, all organs in input are calculated.

if 0 < Z ≤ NIHT, only 1 organ, the Z^{th} organ, is calculated.

Z > NIHT is error.

Y controls zones calculated.

if Y = 0, all zones in input are calculated.

if 0 < Y ≤ MZ, only 1 zone, the Y^{th} zone, is calculated.

Y > MZ is error.

X controls output as follows where an "X" denotes output:

Description[a] X =	0[b]	1	2	3	4	5	6	7–9
SECTION 1. Data Input								
1. Release Model data	X	X	X	X	X	X	X	X
Other input data	X					X		
SECTION 2. Release to Environment								
1. RELOUT						X		
2. R1J		X		X	X	X		X
3. R2TOT			X	X	X	X		
Section 3. Local Dose to Individual								
1. MAN1L					X	X	X	X
Section 4. Nonspecific Dose to Population								
1. MAN1N					X	X	X	X
Section 5. Total Dose by Receptors								
1. MAN2LF, MAN2L; 2. MAN2NF, MAN2N					X	X	X	X
Section 6. Dose Summary Tables								
1. MAN1L; 2. MAN1N					X	X	X	X

[a] See Table 2-1 for further description.

[b] For X = 0, reads in and then outputs all data; no calculations are made.

Section 6 of the output consists of dose summary tables. Each table is a summary for a specific zone (or nonspecific dose) at a specific time. The option controlling the number of zones and times output in this section is controlled by card types 38 to 40 (see Chapter 3). IZONM specifies the number of zones to be tabulated, IZONE identifies the zone number of each zone to be tabulated, ITSUMY specifies the time subscript for the first table and ITSUMJ specifies a time subscript increment for successive tables.

CHAPTER 5

ERROR MESSAGES

There are several error message provisions in AMRAW-A. Each message, its meaning, and corrective action required, is listed below.

Error Message: "ERROR NEAR CHECK POINT (x)(y)"
Meaning: Data which follows error before check point x is not in correct order.
Corrective Action: Check for extra or missing cards and make sure data is in correct order; sort as necessary.

Error Message: "ERROR: ATTEMPTED REPOSITORY OPERATION WITHOUT SUBSEQUENT ENVIRONMENT TIME INCREMENT"
Meaning: Continued operating repository until end of time being studied with no subsequent time in the environment left to study.
Corrective Action: Make ITRE < MT.

Error Message: "ERROR: VALUE OF ZONE (x) OUTSIDE OF RANGE OF MAXIMUM ZONE (y)"
Meaning: Attempted use of nonexistent zone.
Corrective Action: Modify value of 2nd (middle) digit of control parameter NPRINT such that it is ≤ MZ.

Error Message: "ERROR: INVALID ORGAN NUMBER = (x) MAXIMUM NUMBER OF ORGANS = (y)"
Meaning: Attempted to study nonexistent organ.
Corrective Action: Modify right most digit of control parameter NPRINT such that it is ≤ NIHT.

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APPENDIX A

BACKGROUND MATERIAL

The basic structure of the AMRAW model and computer code was developed at UNM between 1972 and 1974 as part of the S. Logan Ph.D. dissertation: "A Technology Assessment Methodology Applied to High-Level Radioactive Waste Management," The University of New Mexico, 1974. Additional development proceeded with support from the Sandia Laboratories University Research Program and from the Energy Resources Board of the State of New Mexico. Completion of the model and code was done under EPA Contract No. 68-01-3256 beginning in August, 1975.

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APPENDIX B

SAMPLE RUN REQUEST

AMRAW-A RUN REQUEST

Requested By: ____________________

Phone: ____________ Date: ____________

Number of Seconds: ________ No. of Ouput Lines: ______

Number of Copies Requested: __________

Special Form? ________ If so, form no. __________

Input Data On: Disk ________ Disk Name: __________

DSN: __________

Card ________ Tape ______ Tape Name: __________

Label: ______ DSN: __________

- -

OFFICE USE ONLY

Date Received: ______________

Date Submitted: ______________

Date Returned: ______________

Initials: __________

APPENDIX C

SAMPLE CODING FORM

Table C-1 presents a sample coding form for AMRAW-A input data illustrating proper formats for the following conditions.

1 nuclide:	C-14
1 zone:	Zone 1
1 organ:	Total Body
Model Branch:	IW = 4, Terminal Storage (beginning at 30 y reference time)
50 Times:	Range from 0 to 10^6 y.

Card types, described in Section 2.A.2., are indicated.

This example is for Zone 1 for the base case described in Part 1 of Vol. II in which it is assumed there is no surface water and no discharge of ground water. If the example were for Zone 2, the value on card type 18 (AREAW) would change from 0.0 to 5.06E+11 and the first 3 values of the second card of type 33 (XL, YW, and YY) would change from 0.0 to 1.00E+04, 2.58E+03, and 5.20E+02, respectively.

The Release Model data (card types 28 to 31) represent 10 cutsets: 3 for each of the first 3 environmental receptors, and 1 for the fourth receptor.

It is assumed that EDC (Environmental Decay Constant) uses internal default values. Hence card type 35 has a value of 1 and card type 36 is omitted.

Table C-1. Sample Coding Form for One Nuclide, One Zone, and One Organ

```
Card  Card                                   FORTRAN STATEMENT                              IDENTIFICATION
Type  Column 5   10        20        30        40        50        60        70        SEQUENCE  80
  1 |    1
  2 | RUN  FOR ONE NUCLIDE, ONE ZONE, ONE ORGAN
  2 |        TITLE MUST HAVE 3 LINES
  2 |               ALWAYS USE 3 EVEN IF 2 ARE BLANK
  3 |    1    1   50    4    8   50    1    1 500     1
  4 |  1.00E-22  1.00E-50  1.00E-35  5.00E+01  1.00E-50  1.00E-10
  5 |  0.00E+00  5.00E+00  1.00E+01  1.50E+01  2.00E+01  2.50E+01  3.00E+01  4.00E+01
  5 |  5.00E+01  6.00E+01  7.00E+01  8.00E+01  9.00E+01  1.00E+02  2.00E+02  3.00E+02
  5 |  4.00E+02  5.00E+02  6.00E+02  7.00E+02  8.00E+02  9.00E+02  1.00E+03  2.00E+03
  5 |  3.00E+03  4.00E+03  5.00E+03  6.00E+03  7.00E+03  8.00E+03  9.00E+03  1.00E+04
  5 |  2.00E+04  3.00E+04  4.00E+04  5.00E+04  6.00E+04  7.00E+04  8.00E+04  9.00E+04
  5 |  1.00E+05  2.00E+05  3.00E+05  4.00E+05  5.00E+05  6.00E+05  7.00E+05  8.00E+05
  5 |  9.00E+05  1.00E+06
  6 |  C
  7 |  1.87E+05
  8 |  4.04E+04
  9 |    C-14 1  0.0         6.14D+01  1.25D+03  4.07D+03  9.99D+03  2.17D+04  4.04D+04
  9 |    C-14 2  4.04D+04  4.04D+04  4.03D+04  4.02D+04  4.02D+04  4.01D+04  4.01D+04
  9 |    C-14 3  3.96D+04  3.91D+04  3.87D+04  3.82D+04  3.77D+04  3.73D+04  3.68D+04
  9 |    C-14 4  3.64D+04  3.59D+04  3.19D+04  2.82D+04  2.50D+04  2.21D+04  1.95D+04
  9 |    C-14 5  1.73D+04  1.54D+04  1.36D+04  1.21D+04  3.75D+03  1.07D+03  3.03D+02
  9 |    C-14 6  8.62D+01  2.49D+01  7.38D+00  2.24D+00  7.02D-01  2.26D-01  2.28D-06
  9 |    C-14 7  7.03D-12  1.50D-17  3.72D-23  0.0       0.0       0.0       0.0
  9 |    C-14 8  0.0
```

Table C-1. (continued)

```
10 ******************* CHECKPOINT NUMBER ONE (1)    ***************************01
11   4.45E+00
12   9.55E-10
13   4.96E-03
14   0.0       0.0       1.00E-09  2.00E+01  0.0       0.0       0.0       0.0
14   0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
14   0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
14   0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
15   1.00E+00
15   7.90E+11
15   0.0
15   1.00E+00
16   1.26E-20
16   1.29E-01
16   0.0
16   0.0
17   4.04E-13
18   0.0
19   1.40E+00
20 ************************  CHECKPOINT NUMBER TWO (2)   **********************02
21     1    4    4    1
22   1.00E+00  7.30E+09
22   4.00E-01  0.0       0.0       0.0       0.0       6.30E+07  0.0       0.0
22   0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
```

Table C-1. (continued)

```
22   0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
23   2.22E-03  5.29E-04  5.33E-04  1.29E-03
23   1.00E+00  1.24E+01  7.68E+00  0.0
23   1.24E+01
24 *************************** CHECK POINT NUMBER THREE (3) *********************03
25 TOT BODY
26   0.0
26   4.24E-01
26   0.0
26   5.69E-01
26   0.0
26   5.69E-01
26   5.69E-01
26   5.69E-01
27 *************************** CHECK POINT NUMBER FOUR (4) **********************04
28     3
29     1    1
30   5.00E-02         0  0.0       0.0
31   1.00E-13
29     2    1
30   7.50E-02         0  0.0       0.0
31   2.40E-12
29     3    1
90   6.00E-03
```

Table C-1. (continued)

```
31    2.40E-12         0  0.0       0.0
28      3
29      1    3
30    3.30E-05
31    1.00E+00         0  0.0       0.0
31    1.00E+00         0  0.0       0.0
31    0.0              2  1.60E+06  1.56E-07
29      2    2
30    5.00E-02
31    1.00E+00         0  0.0       0.0
31    1.00E-13         0  0.0       0.0
29      3    2
30    7.50E-02
31    1.00E+00         0  0.0       0.0
31    8.10E-12         0  0.0       0.0
28      3
29      1    3
30    3.30E-05
31    1.00E+00         0  0.0       0.0
31    1.00E+00         0  0.0       0.0
31    0.0              2  1.60E+06  1.56E-07
29      2    2
30    5.00E-02
31    1.00E+00         0  0.0       0.0
```

Table C-1. (concluded)

```
31   1.00E-13         0  0.0       0.0
29     3    2
30   7.50E-02
31   1.00E+00         0  0.0       0.0
31   8.10E-12         0  0.0       0.0
28     1
29     1    4
30   0.0
31   1.00E+00         0  0.0       0.0
31   1.00E+00         0  0.0       0.0
31   1.00E+00         0  0.0       0.0
31   1.40E-07         0  0.0       0.0
32     1    1
32     1    1    1    1    2    2    2    2
32     1    1    1    1    1    2    2    2
32     1    2
33   4.00E-03  1.50E-01  5.00E+01  6.00E+00  5.00E+01  2.30E+00  4.38E+04  2.22E+05
33   0.0       0.0       0.0       6.25E+04  2.50E+02
34 ************************* CHECK POINT NUMBER FIVE (5) ************************05
35     1
37 ************************* CHECK POINT NUMBER SIX (6)  ************************06
38     1
39     1
40    14    9    1
   //
   /*
```

APPENDIX D

JOB PROCESSING INSTRUCTIONS

1. Prepare jobcard for run using run request as follows:
   Job name - 8 characters alphanumeric serial number.
   Time parameter - number of seconds estimated.
   Lines parameter - number of lines (in thousands) estimated.
   Forms parameter - form number from request.
   Copies parameter - number of copies requested.

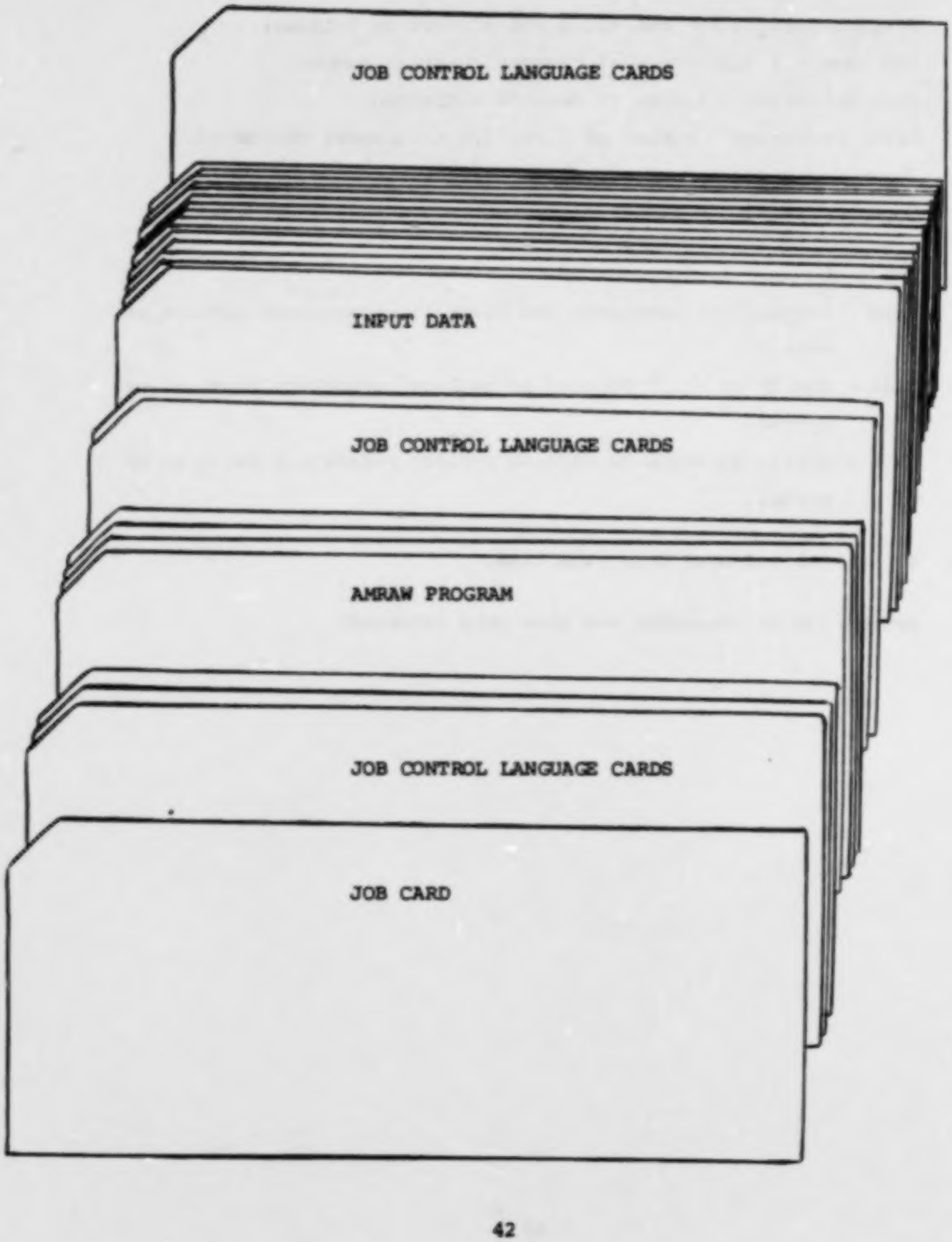
2. Input medium:
   Card - keypunch as necessary and place in appropriate section of deck.
   Disk - modify GO.SYSIN DD card to reflect parameters required by system.
   Tape - modify GO.SYSIN DD card to reflect parameters required by system.

3. Submit job and note date submitted.

4. Return job to requester and note date returned.

APPENDIX E

OPERATING DECK SETUP


JOB CONTROL LANGUAGE CARDS
INPUT DATA
JOB CONTROL LANGUAGE CARDS
AMRAW PROGRAM
JOB CONTROL LANGUAGE CARDS
JOB CARD

APPENDIX F

SAMPLE INPUT AND OUTPUT

Sample input and output is presented for a "short run" using only 3 radionuclides: Sr-90, I-129, and Pb-210. Other parameters are as in a typical "fuel run": 4 environmental receptors, 10 release scenarios (cutsets), 14 environmental pathways, 8 geographic zones, 8 human organs, and 50 time increments.

1. Input Data. Input data is listed according to card input specifications in Section 3.A. and the sample coding forms in Appendix C.

2. Output. Output is separated by partition pages into 6 sections:

(a) *Section 1 - Data Input.* This section, presented in full, is a descriptive output of input data, in the following sequence:

Definition of Environmental Inputs/Definition of Probability Inputs/Probability and Related Data.

Selected Residual Elements in Waste/Selected Radionuclides in Waste.

Ground Water Parameters
EDC
DISPN/ZONALO/ZONDEP
AREAW/ADJ1/ADJ2
VOLINT
BIOFAC
DOSFAC

(b) *Section 2 - Release to Environment.* Sample output is presented for one nuclide (I-129):

Release Fractions by Each Cutset
Release Increments to Preliminary Environment Input Receptors
Concentrations at Environment Input Receptors (Zones 1 and 2 of 8 zones shown)

(c) Section 3 - Local Dose to Individual. Sample output is presented for one nuclide (I-129) and one zone (Zone 1) of 8:

Average Annual Local Dose to Individual

(d) Section 4 - Nonspecific Dose to Population. Sample output is presented for one nuclide (I-129):

Average Annual Nonspecific Dose to Population

(e) Section 5 - Total Dose by Receptors. This section presents totals for all nuclides:

Average Annual Local Dose to Individual. Sample output is presented for 1 organ (Total Body) of 8 and 2 zones (1 and 2) of 8.

Average Annual Nonspecific Dose to Population. Sample output is presented for 1 organ (Total Body).

(f) Section 6 - Dose Summary Tables. These tables summarize dose rates by nuclide to each organ. Sample output is presented for 1 time (1000 y) and 1 zone:

Average Annual Local Dose to Individual, Zone 1

Average Annual Nonspecific Dose to Population

APPENDIX F 1. Input Data

```
 1                                                                                              00000050
                  SHORT RUN BASE CASE FOR TERMINAL STORAGE PHASE                                00000100
                          ALL PROBABILISTIC RELEASES                                            00000150
                     APR. 6. 1978 DATA FILE USED: AMB1              NPRINT=500                  00000200
 03   03   50    4    8   50    5    8   500    1                                               00000250
1.00E-22  1.00E-50  1.00E-35  5.05E+01  1.00E-50  1.00E-10                                      00000300
0.00E+00  5.00E+00  1.00E+01  1.50E+01  2.00E+01  2.50E+01  3.00E+01  4.00E+01                  00000350
5.00E+01  6.00E+01  7.00E+01  8.00E+01  9.00E+01  1.00E+02  2.00E+02  3.00E+02                  00000400
4.00E+02  5.00E+02  6.00E+02  7.00E+02  8.00E+02  9.00E+02  1.00E+03  2.00E+03                  00000450
3.00E+03  4.00E+03  5.00E+03  6.00E+03  7.00E+03  8.00E+03  9.00E+03  1.00E+04                  00000500
2.00E+04  3.00E+04  4.00E+04  5.00E+04  6.00E+04  7.00E+04  8.00E+04  9.00E+04                  00000550
1.00E+05  2.00E+05  3.00E+05  4.00E+05  5.00E+05  6.00E+05  7.00E+05  8.00E+05                  00000600
9.00E+05  1.00E+06                                                                              00000650
SR   1  PB                                                                                      00000700
1.07E+00                                                                                        00000750
1.26E+00  1.84E+05  9.08E+02                                                                    00000800
 SR-90 1  5.36D+05  3.89D+06  1.86D+07  2.24D+07  4.22D+07  7.11D+07  6.28D+07                  00000850
 SR-90 2  4.91D+07  3.98D+07  3.09D+07  2.43D+07  1.91D+07  1.48D+07  1.15D+07                  00000900
 SR-90 3  8.67D+05  7.72D+04  7.62D+03  7.05D+02  7.21D+01  6.18D+00  4.83D-01                  00000950
 SR-90 4  3.65D-02  2.68D-03  1.62D-14  6.95D-25  0.0       0.0       0.0                       00001000
 SR-90 5  0.0       0.0       0.0       0.0       0.0       0.0       0.0                       00001050
 SR-90 6  0.0       0.0       0.0       0.0       0.0       0.0       0.0                       00001100
 SR-90 7  0.0       0.0       0.0       0.0       0.0       0.0       0.0                       00001150
 SR-90 8  0.0                                                                                   00001200
 I-129 1  3.48D+02  2.66D+03  7.98D+03  1.77D+04  3.48D+04  5.85D+04  5.84D+04                  00001250
 I-129 2  5.84D+04  5.84D+04  5.84D+04  5.84D+04  5.84D+04  5.84D+04  5.84D+04                  00001300
 I-129 3  5.84D+04  5.84D+04  5.84D+04  5.84D+04  5.84D+04  5.84D+04  5.84D+04                  00001350
 I-129 4  5.84D+04  5.84D+04  5.84D+04  5.84D+04  5.84D+04  5.84D+04  5.84D+04                  00001400
 I-129 5  5.84D+04  5.84D+04  5.84D+04  5.84D+04  5.83D+04  5.83D+04  5.83D+04                  00001450
 I-129 6  5.83D+04  5.82D+04  5.82D+04  5.82D+04  5.82D+04  5.82D+04  5.80D+04                  00001500
 I-129 7  5.77D+04  5.74D+04  5.72D+04  5.69D+04  5.67D+04  5.65D+04  5.63D+04                  00001550
 I-129 8  5.61D+04                                                                              00001600
PB-210 1  2.12D-07  2.12D-06  9.18D-06  3.99D-05  1.32D-04  3.25D-04  4.51D-04                  00001650
PB-210 2  7.08D-04  9.64D-04  1.26D-03  1.54D-03  1.94D-03  2.35D-03  2.82D-03                  00001700
PB-210 3  1.28D-02  3.68D-02  7.05D-02  1.39D-01  2.28D-01  3.38D-01  4.39D-01                  00001750
PB-210 4  5.75D-01  7.29D-01  2.96D+00  6.06D+00  9.69D+00  1.37D+01  1.79D+01                  00001800
PB-210 5  2.23D+01  2.69D+01  3.18D+01  3.63D+01  8.48D+01  1.27D+02  1.63D+02                  00001850
PB-210 6  1.93D+02  2.19D+02  2.46D+02  2.69D+02  2.74D+02  2.68D+02  3.40D+02                  00001900
PB-210 7  3.08D+02  2.53D+02  1.99D+02  1.55D+02  1.19D+02  9.16D+01  7.07D+01                  00001950
PB-210 8  5.47D+01                                                                              00002000
****************** CHECK POINT NUMBER ONE (1)    ****************************01                 00002050
 1.42E+02  1.63E-04  6.12E+01                                                                   00002100
 1.04E-08  9.82E-10  9.39E-10                                                                   00002150
 2.98E-02  4.95E-03  2.75E-03                                                                   00002200
 0.0       0.0       1.00E-09  2.00E+01  0.0       0.0       0.0       0.0                      00002250
 0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                      00002300
 0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                      00002350
 0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                      00002400
 0.0       0.0       1.00E-09  2.00E+01  0.0       0.0       0.0       0.0                      00002450
 0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                      00002500
 0.0       0.0       0.0       0.0       0.0       0.0       2.00E-01  2.00E+01                 00002550
 0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                      00002600
 0.0       0.0       1.00E-09  2.00E+01  0.0       0.0       0.0       0.0                      00002650
 0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                      00002700
 0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                      00002750
```

```
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                                 00002800
  0.0       0.0       1.00E-09  2.00E+01  0.0       0.0       0.0       0.0                                 00002850
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                                 00002900
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                                 00002950
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                                 00003000
  0.0       0.0       1.00E-09  2.00E+01  0.0       0.0       0.0       0.0                                 00003050
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                                 00003100
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                                 00003150
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                                 00003200
  0.0       0.0       1.00E-09  2.00E+01  0.0       0.0       0.0       0.0                                 00003250
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                                 00003300
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                                 00003350
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                                 00003400
  0.0       0.0       1.00E-09  2.00E+01  0.0       0.0       0.0       0.0                                 00003450
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                                 00003500
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                                 00003550
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                                 00003600
  0.0       0.0       1.00E-09  2.00E+01  0.0       0.0       0.0       0.0                                 00003650
  0.0       0.0       0.0       0.0       5.00E-01  2.00E+01  0.0       0.0                                 00003700
  0.0       0.0       0.0       0.0       0.0       0.0       5.00E-01  2.00E+01                            00003750
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                                 00003800
  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00                            00003850
  7.98E+11  1.01E+14  2.27E+14  4.77E+12  1.22E+14  1.14E+14  1.57E+14  5.44E+12                            00003900
  0.0       8.04E+13  1.14E+14  1.12E+13  3.06E+13  2.05E+13  7.68E+13  2.60E+14                            00003950
  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00                            00004000
  1.38E-20  8.31E-23  5.09E-24  2.12E-24  3.03E-24  3.02E-23  3.18E-24  3.12E-23                            00004050
  1.29E-01  4.01E-01  9.18E-02  8.64E-03  3.00E-02  2.42E-01  4.16E-02  1.44E-02                            00004100
  0.0       2.17E-03  4.60E-04  2.18E-05  9.80E-08  6.88E-04  2.18E-04  1.44E-03                            00004150
  0.0       1.00E+00  0.0       0.0       0.0       0.0       0.0       1.00E+00                            00004200
  4.04E-13  1.92E-15  1.94E-14  1.09E-16  1.79E-16  1.17E-15  1.50E-16  1.29E-15                            00004250
  0.0       5.06E+11  1.14E+12  1.18E+11  3.06E+11  2.05E+11  7.68E+11  2.60E+11                            00004300
  2.00E+01  0.0       4.00E+03                                                                              00004350
****************** CHECK POINT NUMBER TWO (2)    ****************************2                              00004400
   1    4    4    1                                                                                         00004450
  1.00E+00  7.30E+09                                                                                        00004500
  4.00E-01  0.0       0.0       0.0       0.0       6.30E+07  0.0       0.0                                 00004550
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0                                 00004600
  0.0       0.0                                                                                             00004650
  1.00E+00  7.30E+09                                                                                        00004700
  4.00E-01  0.0       0.0       0.0       0.0       1.10E+10  0.0       0.0                                 00004750
  1.00E-03  0.0       0.0       0.0       4.00E+05  5.90E+00  0.0       0.0                                 00004800
  4.00E+03  7.00E+07                                                                                        00004850
  1.00E+00  7.30E+09                                                                                        00004900
  4.00E-01  0.0       0.0       0.0       1.11E+10  1.01E+10  4.67E+08  4.05E+09                            00004950
  1.00E-03  0.0       0.0       0.0       2.00E+05  4.60E+09  4.05E+08  0.0                                 00005000
  0.0       0.0                                                                                             00005050
  1.00E+00  7.30E+09                                                                                        00005100
  4.00E-01  0.0       0.0       0.0       3.98E+09  7.60E+09  8.32E+08  3.21E+09                            00005150
  1.00E-03  0.0       0.0       0.0       0.0       0.0       3.21E+09  0.0                                 00005200
  0.0       0.0                                                                                             00005250
  1.00E+00  7.30E+09                                                                                        00005300
  4.00E-01  0.0       0.0       0.0       2.52E+11  1.02E+10  5.43E+09  1.58E+10                            00005350
  1.00E-03  0.0       0.0       0.0       0.0       0.0       1.50E+10  0.0                                 00005400
  0.0       0.0                                                                                             00005450
  1.00E+00  7.30E+09                                                                                        00005500
```

APPENDIX F   1. Input Data (continued)

```
 4.00E-01  0.0       0.0       0.0       1.97E+13  1.30E+10  1.02E+09  1.50E+10     00005550
 1.00E-03  0.0       0.0       0.0       0.0       0.0       1.00E+10  0.0          00005600
 0.0       0.0                                                                      00005650
 1.00E+00  7.30E+09                                                                 00005700
 4.00E-01  0.0       0.0       0.0       8.02E+09  3.27E+10  7.88E+09  8.31E+10     00005750
 1.00E-03  0.0       0.0       0.0       4.00E+05  1.67E+10  6.31E+10  0.0          00005800
 0.0       0.0                                                                      00005850
 1.00E+00  7.30E+09                                                                 00005900
 4.00E-01  0.0       0.0       0.0       2.84E+09  0.0       6.23E+09  3.46E+10     00005950
 1.00E-03  0.0       0.0       0.0       4.00E+05  9.60E+08  3.46E+10  0.0          00006000
 2.00E+04  4.00E+07                                                                 00006050
 5.26E-01  5.23E-03  3.84E-03  1.84E-02                                             00006100
 1.00E+00  2.40E-01  6.12E-01  0.00                                                 00006150
 2.40E-01                                                                           00006200
 5.26E-01  9.48E-01  2.59E-01  9.86E-02                                             00006250
 1.00E+00  1.16E+00  3.84E+00  0.00                                                 00006300
 1.16E+00                                                                           00006350
 5.26E-01  2.32E-03  1.71E-03  8.62E-03                                             00006400
 1.00E+00  1.16E-01  2.97E-01  0.00                                                 00006450
 1.16E-01                                                                           00006500
****************** CHECK POINT NUMBER THREE (3)   ***************************03     00006550
TOT BODYGI TRACT GONADS  LIVER   LUNGS  MARROW   BONE  THYROID                      00006600
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0         00006650
  1.70E+03  3.84E+01  1.70E+03  0.0       9.71E+03  2.67E+04  2.67E+04  0.0         00006700
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0         00006750
  1.69E+02  4.85E+01  1.69E+02  0.0       0.0       8.43E+03  8.43E+03  0.0         00006800
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0         00006850
  1.69E+02  4.85E+01  1.69E+02  0.0       0.0       8.43E+03  8.43E+03  0.0         00006900
  1.69E+02  4.85E+01  1.69E+02  0.0       0.0       8.43E+03  8.43E+03  0.0         00006950
  1.69E+02  4.85E+01  1.69E+02  0.0       0.0       8.43E+03  8.43E+03  0.0         00007000
  9.55E+07  1.99E+07  1.31E+08  3.60E+07  4.85E+07  1.56E+08  1.45E+08  1.01E+08    00007050
  4.19E+00  8.34E+00  4.19E+00  2.11E+00  6.45E+02  2.40E+00  2.40E+00  8.58E+03    00007100
  5.73E+04  1.19E+04  7.88E+04  2.16E+04  2.51E+04  9.38E+04  8.72E+04  6.04E+04    00007150
  7.22E+00  9.70E+00  7.22E+00  2.01E+00  0.0       3.27E+00  3.27E+00  5.17E+03    00007200
  2.01E+03  4.18E+02  2.74E+03  7.57E+02  1.02E+03  3.29E+03  3.06E+03  2.12E+03    00007250
  7.22E+00  9.70E+00  7.22E+00  2.01E+00  0.0       3.27E+00  3.27E+00  5.17E+03    00007300
  7.22E+00  9.70E+00  7.22E+00  2.01E+00  0.0       3.27E+00  3.27E+00  5.17E+03    00007350
  7.22E+00  9.70E+00  7.22E+00  2.01E+00  0.0       3.27E+00  3.27E+00  5.17E+03    00007400
  1.43E+07  8.75E+06  1.21E+07  7.27E+06  9.02E+06  2.65E+07  2.45E+07  1.20E+07    00007450
  3.40E+03  7.12E+00  3.40E+03  3.10E+04  6.40E+05  3.30E+05  3.30E+05  0.0         00007500
  2.27E+04  5.15E+03  1.92E+04  1.16E+04  1.44E+04  4.23E+04  3.90E+04  1.91E+04    00007550
  5.10E+02  9.70E+00  5.10E+02  4.70E+03  0.0       5.00E+04  5.00E+04  0.0         00007600
  3.00E+02  1.21E+02  2.84E+02  1.83E+02  1.40E+02  5.59E+02  5.15E+02  2.53E+02    00007650
  5.10E+02  9.70E+00  5.10E+02  4.70E+03  0.0       5.60E+04  5.00E+04  0.0         00007700
  5.10E+02  9.70E+00  5.10E+02  4.70E+03  0.0       5.00E+04  5.00E+04  0.0         00007750
  5.10E+02  9.70E+00  5.10E+02  4.70E+03  0.0       5.00E+04  5.00E+04  0.0         00007800
****************** CHECK POINT NUMBER FOUR (4)   ***************************04      00007850
    3                                                                               00007900
    1     1                                                                         00007950
 8.00E-02                                                                           00008000
 1.00E-13          0  0.0        0.0                                                00008050
    2     1                                                                         00008100
 7.50E-02                                                                           00008150
 2.40E-12          0  0.0        0.0                                                00008200
    3     1                                                                         00008250
```

```
6.00E-03                                                                                    00008300
2.40E-12          0  0.0        0.0                                                         00008350
   3                                                                                        00008400
   1      2                                                                                 00008450
3.33E-05                                                                                    00008500
1.00E+00          0  0.0        0.0                                                         00008550
0.0               2  1.60E+06   1.56E-07                                                    00008600
   2      1                                                                                 00008650
5.00E-02                                                                                    00008700
1.00E-13          0  0.0        0.0                                                         00008750
   3      1                                                                                 00008800
7.80E-02                                                                                    00008850
8.10E-12          0  0.0        0.0                                                         00008900
   3                                                                                        00008950
   1      3                                                                                 00009000
3.33E-05                                                                                    00009050
1.00E+00          0  0.0        0.0                                                         00009100
1.00E+00          0  0.0        0.0                                                         00009150
0.0               2  1.60E+06   1.56E-07                                                    00009200
   2      2                                                                                 00009250
5.00E-02                                                                                    00009300
1.00E+00          0  0.0        0.0                                                         00009350
1.00E-13          0  0.0        0.0                                                         00009400
   3      2                                                                                 00009450
7.80E-02                                                                                    00009500
1.00E+00          0  0.0        0.0                                                         00009550
8.10E-12          0  0.0        0.0                                                         00009600
   1                                                                                        00009650
   1      4                                                                                 00009700
0.0                                                                                         00009750
1.00E+00          0  0.0        0.0                                                         00009800
1.00E+00          0  0.0        0.0                                                         00009850
1.00E+00          0  0.0        0.0                                                         00009900
1.40E-07          0  0.0        0.0                                                         00009950
   1      1                                                                                 00010000
   1      1      1      1      2      2      2      2                                      00010050
   1      1      1      1      1      2      2      2                                      00010100
   1      2                                                                                 00010150
 4.00E-03  1.50E-01  8.00E+01  6.00E+00  5.00E+01  2.30E+00  4.30E+04  2.22E+05             00010200
 0.0       1.00E+04  0.0       0.0       0.0       0.0       0.0       2.00E+04             00010250
 0.0       2.58E+03  0.0       0.0       0.0       0.0       0.0       3.64E+03             00010300
 0.0       5.20E+02  0.0       0.0       0.0       0.0       0.0       7.30E+02             00010350
 6.25E+04  2.50E+02                                                                         00010400
****************** CHECK POINT NUMBER FIVE (5)     ***************************05           00010450
   1                                                                                        00010500
****************** CHECK POINT NUMBER SIX  (6)     ***************************06           00010550
   3                                                                                        00010600
   1      8     10                                                                          00010650
  14      9      2                                                                          00010700
```

APPENDIX F   2. Output (a)

```
** DEFINITION OF ENVIRONMENTAL INPUTS                ** DEFINITION OF PROBABILITY INPUTS

      JF     DEFINITION                                  IFLAG    DEFINITION
      --     ----------                                  -----    ----------
      1      AIR                                           0      PROBABILITY (PROB) CONSTANT
      2      GROUND SURFACE                                1      STEP FUNCTION AT TIME TP CHANGES PROB BY AMOUNT CP
      3      SURFACE WATER                                 2      RAMP FUNCTION AT TP CHANGES PROB BY SLOPE CP
      4      GROUND WATER                                  3      EXPONENTIAL FUNCTION AT TP CHANGES PROB BY TIME CONSTANT CP
                                                           4      DELTA FUNCTION, AT TIME TP RELEASE TO ENVIRONMENT IS AA1

** PROBABILITY AND RELATED DATA
   JF       NJF     J      NJJ        AA1           PROB          IFLAG          TP               CP
   --       ---     -      ---        ---           ----          -----          --               --

   1         3      1       1       5.00E-02      1.00E-13          0         0.0              0.0
   1         3      2       1       7.50E-02      2.40E-12          0         0.0              0.0
   1         3      3       1       6.00E-03      2.40E-12          0         0.0              0.0
   2         3      1       2       3.33E-05      1.00E 00          0         0.0              0.0
                                                  0.0               2         1.60000E 06      1.56000E-07
   2         3      2       1       5.00E-02      1.00E-13          0         0.0              0.0
   2         3      3       1       7.50E-02      8.10E-12          0         0.0              0.0
   3         3      1       3       3.33E-08      1.00E 00          0         0.0              0.0
                                                  1.00E 00          0         0.0              0.0
                                                  0.0               2         1.60000E 06      1.56000E-07
   3         3      2       2       5.00E-02      1.00E 00          0         0.0              0.0
                                                  1.00E-13          0         0.0              0.0
   3         3      3       2       7.50E-02      1.00E 00          0         0.0              0.0
                                                  8.10E-12          0         0.0              0.0
   4         1      1       4       0.0           1.00E 00          0         0.0              0.0
                                                  1.00E 00          0         0.0              0.0
                                                  1.00E 00          0         0.0              0.0
                                                  1.40E-07          0         0.0              0.0
****************** CHECK POINT NUMBER FIVE (5)    **************************** 5
****************** CHECK POINT NUMBER SIX  (6)    **************************** 6
```

APPENDIX F 2. Output (a) continued

```
** SELECTED RESIDUAL ELEMENTS IN WASTE
      GRAMS AT START OF TERMINAL STORAGE
FOR TOTAL FUEL =     187000.METRIC TONS

       SR        1.26E 08
        I        1.84E 05
       PB        9.08E 02


** SELECTED RADIONUCLIDES IN WASTE
                GRAMS IN WASTE   VERSUS TIME IN YEARS

     TIME       SR-90      I-129     PB-210
       0.    5.30E 05   3.48E 02   2.12E-07
       5.    3.89E 06   2.66E 03   2.12E-06
      10.    1.06E 07   7.96E 03   9.10E-06
      15.    2.24E 07   1.77E 04   3.90E-05
      20.    4.22E 07   3.40E 04   1.32E-04
      25.    7.11E 07   5.84E 04   3.25E-04
      30.    6.28E 07   5.84E 04   4.51E-04
      40.    4.91E 07   5.84E 04   7.00E-04
      50.    3.90E 07   5.84E 04   9.66E-04
      60.    3.09E 07   5.84E 04   1.26E-03
      70.    2.43E 07   5.84E 04   1.58E-03
      80.    1.91E 07   5.84E 04   1.94E-03
      90.    1.48E 07   5.84E 04   2.35E-03
     100.    1.15E 07   5.84E 04   2.82E-03
     200.    8.87E 05   5.84E 04   1.28E-02
     300.    7.72E 04   5.84E 04   3.68E-02
     400.    7.82E 03   5.84E 04   7.85E-02
     500.    7.85E 02   5.84E 04   1.39E-01
     600.    7.21E 01   5.84E 04   2.20E-01
     700.    6.10E 00   5.84E 04   3.20E-01
     800.    4.83E-01   5.84E 04   4.39E-01
     900.    3.68E-02   5.84E 04   5.75E-01
    1000.    2.68E-03   5.84E 04   7.29E-01
    2000.    1.62E-14   5.84E 04   2.96E 00
    3000.    8.95E-26   5.84E 04   6.06E 00
    4000.    C.0        5.84E 04   9.69E 00
    5000.    0.0        5.84E 04   1.37E 01
    6000.    0.0        5.84E 04   1.79E 01
    7000.    0.0        5.84E 04   2.23E 01
    8000.    0.0        5.84E 04   2.69E 01
    9000.    0.0        5.84E 04   3.15E 01
   10000.    0.0        5.84E 04   3.63E 01
   20000.    0.0        5.83E 04   8.40E 01
   30000.    0.0        5.83E 04   1.27E 02
   40000.    0.0        5.83E 04   1.63E 02
   50000.    0.0        5.83E 04   1.93E 02
   60000.    0.0        5.83E 04   2.19E 02
   70000.    0.0        5.82E 04   2.40E 02
   80000.    0.0        5.82E 04   2.59E 02
   90000.    0.0        5.82E 04   2.74E 02
  100000.    0.0        5.82E 04   2.88E 02
  200000.    0.0        5.80E 04   3.40E 02
  300000.    0.0        5.77E 04   3.08E 02
  400000.    0.0        5.74E 04   2.53E 02
  500000.    0.0        5.72E 04   1.99E 02
  600000.    0.0        5.69E 04   1.55E 02
  700000.    0.0        5.67E 04   1.19E 02
  800000.    0.0        5.65E 04   9.16E 01
  900000.    0.0        5.63E 04   7.07E 01
 1000000.    0.0        5.61E 04   5.47E 01

SPECIFIC ACTIVITY
     CI/G   1.42E 02   1.63E-04   8.12E 01
```

```
RADIONUCLIDE          CC1 DATA          DRC DATA          RKD DATA

    SR-90            1.64E-08          2.90E-02          2.00E 01
    I-129            9.52E-10          4.95E-03          0.0
    PB-210           5.39E-10          2.75E-03          4.00E 03


** GROUND WATER PARAMETERS


   GROUND WATER SEEPAGE VELOCITY, VX, IN METERS/DAY =  4.00E-03
   POROSITY OF SOLID MEDIUM, PORE =  1.50E-01
   BULK SOLID DENSITY, BULKD, IN GRAMS/CUBIC CM =  2.30E 00
   DISPERSIVITY COEFFICIENTS, IN METERS: AXIAL, AL =  5.00E 01  TRANSVERSE, AT =  6.00E 00

   AQUIFER VALUES, IN METERS: HEIGHT, HT=  5.00E 01
   DISTANCE FROM SOURCE TO EMERGENCE, XL(IZ) EFFECTIVE WIDTH, YW(IZ)
   CONCENTRATION AT YY = AVERAGE CONCENTRATION IN YW

    ZONE      IZ= 1      IZ= 2      IZ= 3      IZ= 4      IZ= 5      IZ= 6      IZ= 7      IZ= 8
   XL(IZ)     0.0        1.00E 04   0.0        0.0        0.0        0.0        0.0        2.03E 04
   YW(IZ)     0.0        2.50E 03   0.0        0.0        0.0        0.0        0.0        3.04E 03
   YY(IZ)     0.0        5.20E 02   0.0        0.0        0.0        0.0        0.0        7.30E 02

   EXPOSED AREA OF SOLIDIFIED WASTE SPECIMEN, FS, IN SQUARE CM =  4.30E 04
   VOLUME OF SOLIDIFIED WASTE SPECIMEN, VS, IN CUBIC CM =  2.22E 05
   TOTAL CANISTER INVENTORY, CINV =  6.25E 04
   ASSUMED NUMBER OF CANISTER FAILURES, CFAI =  2.50E 02
```

```
** EDC(K,JP,IZ) DATA, (JP=1,2,3,4), DEFAULT VALUES USED, EXCEPTING NONE   READ IN


 IZ= 1                                            IZ= 2

   SR-90    5.00E 01    2.30E-05    2.30E-05    0.0             5.00E 01    2.30E-05    2.30E-05    0.0
   I-129    5.00E 01    2.30E-05    2.30E-05    0.0             5.00E 01    2.30E-05    2.30E-05    0.0
  PO-210    5.00E 01    2.30E-05    2.30E-05    0.0             5.00E 01    2.30E-05    2.30E-05    0.0

 IZ= 3                                            IZ= 4

   SR-90    5.00E 01    2.30E-05    2.30E-05    0.0             5.00E 01    2.30E-05    2.30E-05    0.0
   I-129    5.00E 01    2.30E-05    2.30E-05    0.0             5.00E 01    2.30E-05    2.30E-05    0.0
  PO-210    5.00E 01    2.30E-05    2.30E-05    0.0             5.00E 01    2.30E-05    2.30E-05    0.0


 IZ= 5                                            IZ= 6

   SR-90    5.00E 01    2.30E-05    2.30E-05    0.0             5.00E 01    2.30E-05    2.30E-05    0.0
   I-129    5.00E 01    2.30E-05    2.30E-05    0.0             5.00E 01    2.30E-05    2.30E-05    0.0
  PO-210    5.00E 01    2.30E-05    2.30E-05    0.0             5.00E 01    2.30E-05    2.30E-05    0.0

 IZ= 7                                            IZ= 8

   SR-90    5.00E 01    2.30E-05    2.30E-05    0.0             5.00E 01    2.30E-05    2.30E-05    0.0
   I-129    5.00E 01    2.30E-05    2.30E-05    0.0             5.00E 01    2.30E-05    2.30E-05    0.0
  PO-210    5.00E 01    2.30E-05    2.30E-05    0.0             5.00E 01    2.30E-05    2.30E-05    0.0
```

APPENDIX F 2. Output (a) continued

```
** DISPH(JF,IZ) DATA, (JF=1,2,3,4)

  IZ= 1                                          IZ= 2
   1.00E 00  7.90E 11  0.0       1.00E 00         1.00E 00  1.01E 14  5.06E 13  1.00E 00

  IZ= 3                                          IZ= 4
   1.00E 00  2.27E 14  1.14E 14  1.00E 00         1.00E 00  4.77E 13  1.12E 13  1.00E 00

  IZ= 5                                          IZ= 6
   1.00E 00  1.22E 14  3.06E 13  1.00E 00         1.00E 00  1.14E 14  2.85E 13  1.00E 00

  IZ= 7                                          IZ= 8
   1.00E 00  1.57E 14  7.68E 13  1.00E 00         1.00E 00  5.46E 12  2.40E 14  1.00E 00


** ZONALO(JF,IZ) DATA, (JF=1,2,3,4)

  IZ= 1                                          IZ= 2
   1.26E-20  1.29E-01  0.0       0.0              5.31E-23  4.41E-01  2.17E-03  1.00E 00

  IZ= 3                                          IZ= 4
   5.09E-24  9.15E-02  4.40E-04  0.0              2.12E-24  8.68E-03  2.16E-05  0.0

  IZ= 5                                          IZ= 6
   3.63E-24  3.59E-02  9.00E-05  0.0              3.03E-23  2.42E-01  6.08E-04  0.0

  IZ= 7                                          IZ= 8
   3.16E-24  4.16E-02  2.10E-04  0.0              3.12E-23  1.46E-02  1.44E-03  1.00E 00


** ZONDEP(IZ) DATA

   IZ= 1     IZ= 2     IZ= 3     IZ= 4     IZ= 5     IZ= 6     IZ= 7     IZ= 8
   4.04E-13  1.93E-15  1.94E-16  1.05E-16  1.79E-16  1.17E-15  1.50E-16  1.25E-15
```

```
** AREAW(IZ) DATA

IZ= 1      IZ= 2      IZ= 3      IZ= 4      IZ= 5      IZ= 6      IZ= 7      IZ= 8
0.0        8.06E 11   1.14E 12   1.12E 11   3.06E 11   2.85E 11   7.88E 11   5.40E 11

** ADJ1(JF,JFA,IZ),ADJ2(JF,JFA,IZ) DATA, (JFA=1,2,3,4)

IZ= 1
  JF= 1    0.0      0.0      1.00E-09   2.00E 01   0.0        0.0        0.0        0.0
  JF= 2    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
  JF= 3    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
  JF= 4    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
IZ= 2
  JF= 1    0.0      0.0      1.00E-09   2.00E 01   0.0        0.0        0.0        0.0
  JF= 2    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
  JF= 3    0.0      0.0      0.0        0.0        0.0        0.0        2.00E-01   2.00E 01
  JF= 4    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
IZ= 3
  JF= 1    0.0      0.0      1.00E-09   2.00E 01   0.0        0.0        0.0        0.0
  JF= 2    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
  JF= 3    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
  JF= 4    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
IZ= 4
  JF= 1    0.0      0.0      1.00E-09   2.00E 01   0.0        0.0        0.0        0.0
  JF= 2    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
  JF= 3    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
  JF= 4    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
IZ= 5
  JF= 1    0.0      0.0      1.00E-09   2.00E 01   0.0        0.0        0.0        0.0
  JF= 2    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
  JF= 3    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
  JF= 4    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
IZ= 6
  JF= 1    0.0      0.0      1.00E-09   2.00E 01   0.0        0.0        0.0        0.0
  JF= 2    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
  JF= 3    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
  JF= 4    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
IZ= 7
  JF= 1    0.0      0.0      1.00E-09   2.00E 01   0.0        0.0        0.0        0.0
  JF= 2    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
  JF= 3    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
  JF= 4    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
IZ= 8
  JF= 1    0.0      0.0      1.00E-09   2.00E 01   0.0        0.0        0.0        0.0
  JF= 2    0.0      0.0      0.0        0.0        5.00E-01   2.00E 01   0.0        0.0
  JF= 3    0.0      0.0      0.0        0.0        0.0        0.0        8.00E-01   2.00E 01
  JF= 4    0.0      0.0      0.0        0.0        0.0        0.0        0.0        0.0
```

APPENDIX F   2. Output (a) continued

```
** VOLINT(JP,MODE,NSP) DATA

 IZ= 1
   JP       MODE      NSP=1 THRU          VOLINT
    1         1             1     1.00E 00
    1         2             1     7.30E 09
    2         1             4     4.00E-01      0.0          0.0          0.0
    2         2             4     0.0           6.30E 07     0.0          0.0
    3         1             4     0.0           0.0          0.0          0.0
    3         2             4     0.0           0.0          0.0          0.0
    4         1             1     0.0
    4         2             1     0.0
 IZ= 2
   JP       MODE      NSP=1 THRU          VOLINT
    1         1             1     1.00E 00
    1         2             1     7.30E 09
    2         1             4     4.00E-01      0.0          0.0          0.0
    2         2             4     0.0           1.18E 10     0.0          0.0
    3         1             4     1.00E-03      0.0          0.0          0.0
    3         2             4     4.00E 05      8.90E 09     0.0          0.0
    4         1             1     4.60E 03
    4         2             1     7.08E 07
 IZ= 3
   JP       MODE      NSP=1 THRU          VOLINT
    1         1             1     1.00E 00
    1         2             1     7.30E 09
    2         1             4     4.00E-01      0.0          0.0          0.0
    2         2             4     1.11E 10      1.61E 10     4.67E 08     4.08E 09
    3         1             4     1.00E-03      0.0          0.0          0.0
    3         2             4     2.00E 05      4.60E 09     4.08E 09     0.0
    4         1             1     0.0
    4         2             1     0.0
 IZ= 4
   JP       MODE      NSP=1 THRU          VOLINT
    1         1             1     1.00E 00
    1         2             1     7.30E 09
    2         1             4     4.00E-01      0.0          0.0          0.0
    2         2             4     3.95E 09      7.60E 09     8.38E 08     3.21E 09
    3         1             4     1.00E-03      0.0          0.0          0.0
    3         2             4     0.0           0.0          3.21E 09     0.0
    4         1             1     0.0
    4         2             1     0.0
```

```
IZ= 5
   JP       MODE      NSP=1 THRU         VOLINT
    1         1               1       1.00E 00
    1         2               1       7.30E 09
    2         1               4       4.00E-01      0.0          0.0          0.0
    2         2               4       2.52E 11      1.02E 10     5.43E 09     1.58E 10
    3         1               4       1.00E-03      0.0          0.0          0.0
    3         2               4       0.0           0.0          1.58E 10     0.0
    4         1               1       0.0
    4         2               1       0.0
IZ= 6
   JP       MODE      NSP=1 THRU         VOLINT
    1         1               1       1.00E 00
    1         2               1       7.30E 09
    2         1               4       4.00E-01      0.0          0.0          0.0
    2         2               4       1.97E 10      1.38E 10     1.92E 09     1.50E 10
    3         1               4       1.00E-03      0.0          0.0          0.0
    3         2               4       0.0           0.0          1.50E 10     0.0
    4         1               1       0.0
    4         2               1       0.0
IZ= 7
   JP       MODE      NSP=1 THRU         VOLINT
    1         1               1       1.00E 00
    1         2               1       7.30E 09
    2         1               4       4.00E-01      0.0          0.0          0.0
    2         2               4       5.82E 09      3.27E 10     7.68E 09     6.31E 10
    3         1               4       1.00E-03      0.0          0.0          0.0
    3         2               4       4.00E 05      1.67E 10     6.31E 10     0.0
    4         1               1       0.0
    4         2               1       0.0
IZ= 8
   JP       MODE      NSP=1 THRU         VOLINT
    1         1               1       1.00E 00
    1         2               1       7.30E 09
    2         1               4       4.00E-01      0.0          0.0          0.0
    2         2               4       2.84E 09      0.0          6.23E 09     3.46E 10
    3         1               4       1.00E-03      0.0          0.0          0.0
    3         2               4       4.00E 05      9.68E 08     3.46E 10     0.0
    4         1               1       2.00E 04
    4         2               1       4.80E 07
```

```
** BIOFAC(K,JF,NSP) DATA

RADIONUCLIDE=   SR-90
    JF      NSP=1 THRU             BIOFAC
     1               1     1.00E 00
     2               4     5.26E-01     5.23E-03     3.56E-03     1.84E-02
     3               4     1.00E 00     2.40E-01     5.12E-01     0.0
     4               1     2.40E-01
RADIONUCLIDE=   I-129
    JF      NSP=1 THRU             BIOFAC
     1               1     1.00E 00
     2               4     5.26E-01     9.40E-01     2.09E-01     9.86E-02
     3               4     1.00E 00     1.16E 00     3.84E 00     0.0
     4               1     1.16E 00
RADIONUCLIDE=  PB-210
    JF      NSP=1 THRU             BIOFAC
     1               1     1.00E 00
     2               4     5.26E-01     2.32E-03     1.71E-03     5.62E-03
     3               4     1.00E 00     1.16E-01     3.97E-01     0.0
     4               1     1.16E-01
```

APPENDIX F   2. Output (a) continued

```
** DOSFAC(K,JF,MODE,IH) DATA

ORGAN = TOT BODY
                             JF=1                                JF=2                                JF=3                                JF=4
               MODE=1                  MODE=2      MODE=1                  MODE=2      MODE=1                  MODE=2      MODE=1                  MODE=2
   SR-90       0.0                     1.78E 03    0.0                     1.69E 02    0.0                     1.69E 02    1.69E 02                1.69E 02
   I-129       9.55E 07                4.19E 00    5.72E 04                7.22E 00    2.01E 03                7.22E 00    7.22E 00                7.22E 00
  PB-210       1.43E 07                3.40E 03    2.27E 04                5.10E 02    3.00E 02                5.10E 02    5.10E 02                5.10E 02

ORGAN = GI TRACT
                             JF=1                                JF=2                                JF=3                                JF=4
               MODE=1                  MODE=2      MODE=1                  MODE=2      MODE=1                  MODE=2      MODE=1                  MODE=2
   SR-90       0.0                     3.56E 01    0.0                     4.85E 01    0.0                     4.85E 01    4.85E 01                4.85E 01
   I-129       1.98E 07                5.34E 00    1.19E 04                9.7UE 00    4.18E 02                9.70E 00    9.70E 00                9.70E 00
  PB-210       5.78E 06                7.12E 00    9.15E 03                9.70E 00    1.21E 02                9.70E 00    9.70E 00                9.70E 00


ORGAN =  GONADS
                             JF=1                                JF=2                                JF=3                                JF=4
               MODE=1                  MODE=2      MODE=1                  MODE=2      MODE=1                  MODE=2      MODE=1                  MODE=2
   SR-90       0.0                     1.78E 03    0.0                     1.69E 02    0.0                     1.69E 02    1.69E 02                1.69E 02
   I-129       1.31E 08                4.19E 00    7.88E 04                7.22E 00    2.74E 03                7.22E 00    7.22E 00                7.22E 00
  PB-210       1.21E 07                3.40E 03    1.92E 04                5.10E 02    2.94E 02                5.10E 02    5.10E 02                5.10E 02

ORGAN =  LIVER
                             JF=1                                JF=2                                JF=3                                JF=4
               MODE=1                  MODE=2      MODE=1                  MODE=2      MODE=1                  MODE=2      MODE=1                  MODE=2
   SR-90       0.0                     0.0         0.0                     0.0         0.0                     0.0         0.0                     0.0
   I-129       3.60E 07                2.11E 00    2.16E 04                2.81E 00    7.57E 02                2.81E 00    2.81E 00                2.81E 00
  PB-210       7.27E 06                3.10E 04    1.16E 04                4.70E 03    1.53E 02                4.70E 03    4.70E 03                4.70E 03
```

APPENDIX F   2. Output (a) concluded

```
ORGAN =   LUNGS
                                   JF=1                                       JF=2                                       JF=3                                       JF=4
            MODE=1           MODE=2            MODE=1           MODE=2            MODE=1           MODE=2            MODE=1           MODE=2
   SR-90    0.0              9.71E 03          0.0              0.0               0.0              0.0               0.0              0.0
   I-129    4.05E 07         4.48E 02          2.51E 04         0.0               1.02E 03         0.0               0.0              0.0
  PO-210    9.02E 06         6.40E 05          1.44E 04         0.0               1.90E 02         0.0               0.0              0.0
ORGAN =  MARROW
                                   JF=1                                       JF=2                                       JF=3                                       JF=4
            MODE=1           MODE=2            MODE=1           MODE=2            MODE=1           MODE=2            MODE=1           MODE=2
   SR-90    0.0              2.67E 04          0.0              8.43E 03          0.0              8.43E 03          8.43E 03         8.43E 03
   I-129    1.86E 08         2.48E 00          9.34E 04         3.27E 00          3.29E 03         3.27E 00          3.27E 00         3.27E 00
  PO-210    2.65E 07         3.36E 05          4.23E 04         5.00E 04          5.59E 02         5.00E 04          5.03E 04         5.00E 04



ORGAN =   BONE
                                   JF=1                                       JF=2                                       JF=3                                       JF=4
            MODE=1           MODE=2            MODE=1           MODE=2            MODE=1           MODE=2            MODE=1           MODE=2
   SR-90    0.0              2.67E 04          0.0              8.43E 03          0.0              8.43E 03          8.43E 03         8.43E 03
   I-129    1.45E 08         2.48E 00          8.72E 04         3.27E 00          3.06E 03         3.27E 00          3.27E 00         3.27E 00
  PO-210    2.45E 07         3.36E 05          3.96E 04         5.00E 04          5.15E 02         5.00E 04          5.00E 04         5.00E 04
ORGAN = THYROID
                                   JF=1                                       JF=2                                       JF=3                                       JF=4
            MODE=1           MODE=2            MODE=1           MODE=2            MODE=1           MODE=2            MODE=1           MODE=2
   SR-90    0.0              0.0               0.0              0.0               0.0              0.0               0.0              0.0
   I-129    1.01E 08         5.85E 03          6.04E 04         5.17E 03          2.12E 03         5.17E 03          5.17E 03         5.17E 03
  PO-210    1.20E 07         0.0               1.91E 04         0.0               2.53E 02         0.0               0.0              0.0
```

APPENDIX F   2. Output (b)

```
RADIONUCLIDE:    I-129 (K =  2)
-----------------------------------

RELEASE FRACTIONS BY EACH CUTSET, RELOUT

TIME            #     INITIAL RELEASE FRACTIONS
       40.      1     5.00E-14      1.80E-12      1.44E-13
       40.      2     0.0           5.00E-14      6.07E-12
       40.      3     0.0           5.00E-14      6.07E-12
       40.      4     9.97E-12
       50.      1     5.00E-14      1.80E-12      1.44E-13
       50.      2     0.0           5.00E-14      6.07E-12
       50.      3     0.0           5.00E-14      6.07E-12
       50.      4     9.97E-12
       60.      1     5.00E-14      1.80E-12      1.44E-13
       60.      2     0.0           5.00E-14      6.07E-12
       60.      3     0.0           5.00E-14      6.07E-12
       60.      4     9.97E-12
       70.      1     5.00E-14      1.80E-12      1.44E-13
       70.      2     0.0           5.00E-14      6.07E-12
       70.      3     0.0           5.00E-14      6.07E-12
       70.      4     9.97E-12
       80.      1     5.00E-14      1.80E-12      1.44E-13
       80.      2     0.0           5.00E-14      6.07E-12
       80.      3     0.0           5.00E-14      6.07E-12
       80.      4     9.97E-12
       90.      1     5.00E-14      1.80E-12      1.44E-13
       90.      2     0.0           5.00E-14      6.07E-12
       90.      3     0.0           5.00E-14      6.07E-12
       90.      4     9.97E-12
      100.      1     5.00E-14      1.80E-12      1.44E-13
      100.      2     0.0           5.00E-14      6.07E-12
      100.      3     0.0           5.00E-14      6.07E-12
      100.      4     9.97E-12
      200.      1     5.00E-13      1.80E-11      1.44E-12
      200.      2     0.0           5.00E-13      6.07E-11
      200.      3     0.0           5.00E-13      6.07E-11
      200.      4     9.00E-10
      300.      1     5.00E-13      1.80E-11      1.44E-12
      300.      2     0.0           5.00E-13      6.07E-11
      300.      3     0.0           5.00E-13      6.07E-11
      300.      4     9.00E-10
      400.      1     5.00E-13      1.80E-11      1.44E-12
      400.      2     0.0           5.00E-13      6.07E-11
      400.      3     0.0           5.00E-13      6.07E-11
      400.      4     9.00E-10
      500.      1     5.00E-13      1.80E-11      1.44E-12
      500.      2     0.0           5.00E-13      6.07E-11
      500.      3     0.0           5.00E-13      6.07E-11
      500.      4     9.00E-10
      600.      1     5.00E-13      1.80E-11      1.44E-12
      600.      2     0.0           5.00E-13      6.07E-11
      600.      3     0.0           5.00E-13      6.07E-11
      600.      4     9.00E-10
      700.      1     5.00E-13      1.80E-11      1.44E-12
      700.      2     0.0           5.00E-13      6.07E-11
      700.      3     0.0           5.00E-13      6.07E-11
      700.      4     9.00E-10
      800.      1     5.00E-13      1.80E-11      1.44E-12
      800.      2     0.0           5.00E-13      6.07E-11
      800.      3     0.0           5.00E-13      6.07E-11
      800.      4     9.00E-10
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This table continues through 1,000,000 years.

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RADIONUCLIDE:    I-129 (K= 2)
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RELEASE INCREMENTS TO PRELIMINARY ENVIRONMENT INPUT
RECEPTORS, RIJ, FROM ALL RELEASE EVENTS, IN CURIES

              JF=1         JF=2         JF=3         JF=4
    TIME      AIR          GROUND       SURFACE      GROUND
                           SURFACE      WATER        WATER
      0.   0.0          0.0          0.0          0.0
      5.   0.0          0.0          0.0          0.0
     10.   0.0          0.0          0.0          0.0
     15.   0.0          0.0          0.0          0.0
     20.   0.0          0.0          0.0          0.0
     25.   0.0          0.0          0.0          0.0
     30.   0.0          0.0          0.0          0.0
     40.   1.90E-11     8.83E-11     8.83E-11     9.49E-11
     50.   1.90E-11     8.83E-11     8.83E-11     9.49E-11
     60.   1.90E-11     8.83E-11     8.83E-11     9.49E-11
     70.   1.90E-11     8.83E-11     8.83E-11     9.49E-11
     80.   1.90E-11     8.83E-11     8.83E-11     9.49E-11
     90.   1.90E-11     8.83E-11     8.83E-11     9.49E-11
    100.   1.90E-11     8.83E-11     8.83E-11     9.49E-11
    200.   1.90E-10     8.83E-10     8.83E-10     8.56E-09
    300.   1.90E-10     8.83E-10     8.83E-10     8.56E-09
    400.   1.90E-10     8.83E-10     8.83E-10     8.56E-09
    500.   1.90E-10     8.83E-10     8.83E-10     8.56E-09
    600.   1.90E-10     8.83E-10     8.83E-10     8.56E-09
    700.   1.90E-10     8.83E-10     8.83E-10     8.56E-09
    800.   1.90E-10     8.83E-10     8.83E-10     8.56E-09
    900.   1.90E-10     8.83E-10     8.83E-10     8.56E-09
   1000.   1.90E-10     8.83E-10     8.83E-10     8.56E-09
   2000.   1.90E-09     8.83E-09     8.83E-09     8.36E-07
   3000.   1.90E-09     8.83E-09     8.83E-09     8.36E-07
   4000.   1.90E-09     8.83E-09     8.83E-09     8.36E-07
   5000.   1.90E-09     8.83E-09     8.83E-09     8.36E-07
   6000.   1.90E-09     8.83E-09     8.83E-09     8.36E-07
   7000.   1.90E-09     8.83E-09     8.83E-09     8.36E-07
   8000.   1.90E-09     8.83E-09     8.83E-09     8.36E-07
   9000.   1.90E-09     8.83E-09     8.83E-09     8.36E-07
  10000.   1.90E-09     8.83E-09     8.83E-09     8.36E-07
  20000.   1.90E-08     8.83E-08     8.83E-08     8.33E-05
  30000.   1.89E-08     8.82E-08     8.82E-08     8.32E-05
  40000.   1.89E-08     8.82E-08     8.82E-08     8.32E-05
  50000.   1.89E-08     8.82E-08     8.82E-08     8.32E-05
  60000.   1.89E-08     8.82E-08     8.82E-08     8.32E-05
  70000.   1.89E-08     8.82E-08     8.82E-08     8.31E-05
  80000.   1.89E-08     8.81E-08     8.81E-08     8.31E-05
  90000.   1.89E-08     8.81E-08     8.81E-08     8.31E-05
 100000.   1.89E-08     8.81E-08     8.81E-08     8.31E-05
 200000.   1.89E-07     8.80E-07     8.80E-07     8.29E-03
 300000.   1.88E-07     8.78E-07     8.78E-07     8.26E-03
 400000.   1.87E-07     8.75E-07     8.75E-07     8.21E-03
 500000.   1.86E-07     8.72E-07     8.72E-07     8.18E-03
 600000.   1.85E-07     8.70E-07     8.70E-07     8.14E-03
 700000.   1.85E-07     8.67E-07     8.67E-07     8.11E-03
 800000.   1.84E-07     8.65E-07     8.65E-07     8.08E-03
 900000.   1.83E-07     8.63E-07     8.63E-07     8.06E-03
1000000.   1.82E-07     8.61E-07     8.61E-07     8.03E-03
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APPENDIX F

2. Output (b) continued

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RADIONUCLIDE:    I-129 (K= 2)
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CONCENTRATIONS AT ENVIRONMENT INPUT RECEPTOR, R2TUT     UNITS: JF=1 MICROCURIE*YEARS/CUBIC CM
JF=2 MICROCURIES/SQUARE CM, JF=3 AND 4 MICROCURIES/CUBIC CM

ZONE= 1                                                   ZONE= 2

            JF=1      JF=2      JF=3      JF=4                        JF=1      JF=2      JF=3      JF=4
      TIME  AIR       GROUND    SURFACE   GROUND                TIME  AIR       GROUND    SURFACE   GROUND
                      SURFACE   WATER     WATER                                 SURFACE   WATER     WATER
        0.  0.0       0.0       0.0       0.0                     0.  0.0       0.0       0.0       0.0
        5.  0.0       0.0       0.0       0.0                     5.  0.0       0.0       0.0       0.0
       10.  0.0       0.0       0.0       0.0                    10.  0.0       0.0       0.0       0.0
       15.  0.0       0.0       0.0       0.0                    15.  0.0       0.0       0.0       0.0
       20.  0.0       0.0       0.0       0.0                    20.  0.0       0.0       0.0       0.0
       25.  0.0       0.0       0.0       0.0                    25.  0.0       0.0       0.0       0.0
       30.  0.0       0.0       0.0       0.0                    30.  0.0       0.0       0.0       0.0
       40.  4.11E-25  1.72E-17  0.0       0.0                    40.  3.92E-27  2.91E-19  2.87E-21  0.0
       50.  5.83E-25  3.44E-17  0.0       0.0                    50.  6.83E-27  5.82E-19  5.73E-21  0.0
       60.  7.55E-25  5.16E-17  0.0       0.0                    60.  9.74E-27  8.73E-19  8.60E-21  0.0
       70.  9.26E-25  6.87E-17  0.0       0.0                    70.  1.27E-26  1.16E-18  1.15E-20  0.0
       80.  1.10E-24  8.59E-17  0.0       0.0                    80.  1.56E-26  1.46E-18  1.43E-20  0.0
       90.  1.27E-24  1.03E-16  0.0       0.0                    90.  1.85E-26  1.75E-18  1.72E-20  0.0
      100.  1.44E-24  1.20E-16  0.0       0.0                   100.  2.14E-26  2.04E-18  2.01E-20  0.0
      200.  3.16E-23  2.92E-16  0.0       0.0                   200.  5.05E-25  4.95E-18  4.87E-20  0.0
      300.  4.87E-23  4.63E-16  0.0       0.0                   300.  7.95E-25  7.85E-18  7.73E-20  0.0
      400.  6.58E-23  6.34E-16  0.0       0.0                   400.  1.08E-24  1.07E-17  1.06E-19  0.0
      500.  8.28E-23  8.04E-16  0.0       0.0                   500.  1.37E-24  1.36E-17  1.34E-19  0.0
      600.  9.98E-23  9.75E-16  0.0       0.0                   600.  1.66E-24  1.65E-17  1.63E-19  0.0
      700.  1.17E-22  1.14E-15  0.0       0.0                   700.  1.95E-24  1.94E-17  1.91E-19  0.0
      800.  1.34E-22  1.31E-15  0.0       0.0                   800.  2.24E-24  2.23E-17  2.19E-19  0.0
      900.  1.51E-22  1.48E-15  0.0       0.0                   900.  2.52E-24  2.51E-17  2.47E-19  0.0
     1000.  1.67E-22  1.65E-15  0.0       0.0                  1000.  2.81E-24  2.80E-17  2.75E-19  0.0
     2000.  3.37E-21  3.35E-15  0.0       0.0                  2000.  5.68E-23  5.67E-17  5.59E-19  0.0
     3000.  5.02E-21  4.99E-15  0.0       0.0                  3000.  8.47E-23  8.46E-17  8.33E-19  1.67E-35
     4000.  6.62E-21  6.60E-15  0.0       0.0                  4000.  1.12E-22  1.12E-16  1.10E-18  3.00E-25
     5000.  8.19E-21  8.17E-15  0.0       0.0                  5000.  1.38E-22  1.38E-16  1.37E-18  3.70E-20
     6000.  9.72E-21  9.70E-15  0.0       0.0                  6000.  1.64E-22  1.64E-16  2.74E-18  9.97E-18
     7000.  1.12E-20  1.12E-14  0.0       0.0                  7000.  1.90E-22  1.90E-16  1.46E-17  1.05E-16
     8000.  1.27E-20  1.27E-14  0.0       0.0                  8000.  2.15E-22  2.15E-16  9.16E-17  6.90E-16
     9000.  1.41E-20  1.41E-14  0.0       0.0                  9000.  2.39E-22  2.39E-16  3.51E-16  2.34E-15
    10000.  1.55E-20  1.55E-14  0.0       0.0                 10000.  2.63E-22  2.62E-16  7.74E-16  3.05E-15
    20000.  3.08E-19  3.08E-14  0.0       0.0                 20000.  5.22E-21  5.22E-16  1.03E-15  3.08E-16
    30000.  4.16E-19  4.16E-14  0.0       0.0                 30000.  7.05E-21  7.05E-16  5.14E-15  3.87E-15
    40000.  5.03E-19  5.02E-14  0.0       0.0                 40000.  8.51E-21  8.51E-16  8.40E-15  3.86E-15
    50000.  5.71E-19  5.71E-14  0.0       0.0                 50000.  9.67E-21  9.67E-16  1.10E-14  3.86E-15
    60000.  6.25E-19  6.25E-14  0.0       0.0                 60000.  1.06E-20  1.06E-15  1.31E-14  3.86E-15
    70000.  6.68E-19  6.68E-14  0.0       0.0                 70000.  1.13E-20  1.13E-15  1.47E-14  3.86E-15
    80000.  7.02E-19  7.01E-14  0.0       0.0                 80000.  1.19E-20  1.19E-15  1.60E-14  3.86E-15
    90000.  7.29E-19  7.29E-14  0.0       0.0                 90000.  1.23E-20  1.23E-15  1.70E-14  3.86E-15
   100000.  7.50E-19  7.50E-14  0.0       0.0                100000.  1.27E-20  1.27E-15  1.78E-14  3.86E-15
   200000.  1.92E-17  1.92E-13  0.0       0.0                200000.  3.26E-19  3.26E-15  5.52E-15  4.20E-17
   300000.  1.89E-17  1.89E-13  0.0       0.0                300000.  3.21E-19  3.21E-15  4.74E-14  4.19E-15
   400000.  1.88E-17  1.88E-13  0.0       0.0                400000.  3.19E-19  3.19E-15  5.13E-14  4.17E-15
   500000.  1.87E-17  1.87E-13  0.0       0.0                500000.  3.18E-19  3.18E-15  5.15E-14  4.15E-15
   600000.  1.87E-17  1.87E-13  0.0       0.0                600000.  3.16E-19  3.16E-15  5.13E-14  4.13E-15
   700000.  1.86E-17  1.86E-13  0.0       0.0                700000.  3.15E-19  3.15E-15  5.11E-14  4.12E-15
   800000.  1.85E-17  1.85E-13  0.0       0.0                800000.  3.14E-19  3.14E-15  5.09E-14  4.10E-15
   900000.  1.85E-17  1.85E-13  0.0       0.0                900000.  3.13E-19  3.13E-15  5.07E-14  4.08E-15
  1000000.  1.84E-17  1.84E-13  0.0       0.0               1000000.  3.11E-19  3.11E-15  5.05E-14  4.07E-15
```

APPENDIX F 2. Output (c)

```
** AVERAGE ANNUAL LOCAL DOSE TO INDIVIDUAL, MANIL. IN MILLIREMS/YEAR

ZONE= 1... NUCLIDE=   I-129  K=  2

     TIME   TOT BODY   GI TRACT    GONADS     LIVER      LUNGS      MARROW     BONE       THYROID
       0.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
       5.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
      10.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
      15.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
      20.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
      25.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
      30.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
      40.   3.98E-13   8.34E-14   5.43E-13   1.49E-13   3.34E-13   6.46E-13   6.00E-13   2.08E-12
      50.   7.90E-13   1.66E-13   1.09E-12   2.58E-13   5.89E-13   1.29E-12   1.20E-12   3.19E-12
      60.   1.10E-12   2.48E-13   1.63E-12   4.47E-13   8.45E-13   1.94E-12   1.80E-12   4.30E-12
      70.   1.58E-12   3.31E-13   2.17E-12   5.95E-13   1.10E-12   2.58E-12   2.40E-12   5.41E-12
      80.   1.97E-12   4.13E-13   2.71E-12   7.44E-13   1.36E-12   3.23E-12   3.00E-12   6.52E-12
      90.   2.37E-12   4.98E-13   3.28E-12   8.93E-13   1.61E-12   3.87E-12   3.60E-12   7.64E-12
     100.   2.76E-12   5.78E-13   3.79E-12   1.04E-12   1.87E-12   4.51E-12   4.20E-12   8.75E-12
     200.   6.70E-12   1.40E-12   9.21E-12   2.53E-12   4.42E-12   1.10E-11   1.02E-11   1.99E-11
     300.   1.06E-11   2.22E-12   1.46E-11   4.01E-12   6.97E-12   1.74E-11   1.62E-11   3.09E-11
     400.   1.46E-11   3.04E-12   2.00E-11   5.49E-12   9.52E-12   2.38E-11   2.21E-11   4.20E-11
     500.   1.85E-11   3.86E-12   2.54E-11   6.96E-12   1.21E-11   3.02E-11   2.81E-11   5.30E-11
     600.   2.24E-11   4.68E-12   3.07E-11   8.44E-12   1.46E-11   3.66E-11   3.40E-11   6.40E-11
     700.   2.63E-11   5.49E-12   3.61E-11   9.90E-12   1.71E-11   4.30E-11   3.99E-11   7.50E-11
     800.   3.01E-11   6.30E-12   4.14E-11   1.14E-11   1.96E-11   4.93E-11   4.58E-11   8.59E-11
     900.   3.40E-11   7.11E-12   4.68E-11   1.29E-11   2.21E-11   5.56E-11   5.17E-11   9.68E-11
    1000.   3.79E-11   7.92E-12   5.21E-11   1.43E-11   2.47E-11   6.20E-11   5.76E-11   1.08E-10
    2000.   7.69E-11   1.61E-11   1.06E-10   2.90E-11   4.99E-11   1.26E-10   1.17E-10   2.18E-10
    3000.   1.18E-10   2.40E-11   1.57E-10   4.32E-11   7.44E-11   1.87E-10   1.74E-10   3.24L-10
    4000.   1.51E-10   3.17E-11   2.08E-10   5.71E-11   9.83E-11   2.48E-10   2.30E-10   4.28E-10
    5000.   1.87E-10   3.92E-11   2.58E-10   7.07E-11   1.22E-10   3.07E-10   2.85E-10   5.29E-10
    6000.   2.23E-10   4.65E-11   3.06E-10   8.40E-11   1.44E-10   3.64E-10   3.38E-10   6.28E-10
    7000.   2.57E-10   5.37E-11   3.53E-10   9.69E-11   1.67E-10   4.20E-10   3.91E-10   7.25E-10
    8000.   2.91E-10   6.08E-11   3.99E-10   1.10E-10   1.89E-10   4.75E-10   4.42E-10   8.20E-10
    9000.   3.23E-10   6.76E-11   4.45E-10   1.22E-10   2.10E-10   5.29E-10   4.92E-10   9.12E-10
   10000.   3.56E-10   7.43E-11   4.89E-10   1.34E-10   2.31E-10   5.82E-10   5.41E-10   1.00E-09
   20000.   7.07E-10   1.48E-10   9.72E-10   2.67E-10   4.59E-10   1.16E-09   1.08E-09   1.99E-09
   30000.   9.58E-10   2.00E-10   1.31E-09   3.60E-10   6.20E-10   1.56E-09   1.45E-09   2.69E-09
   40000.   1.15E-09   2.41E-10   1.58E-09   4.35E-10   7.48E-10   1.89E-09   1.75E-09   3.25E-09
   50000.   1.31E-09   2.74E-10   1.80E-09   4.94E-10   8.50E-10   2.14E-09   1.99E-09   3.69E-09
   60000.   1.43E-09   3.00E-10   1.97E-09   5.41E-10   9.31E-10   2.35E-09   2.18E-09   4.04E-09
   70000.   1.53E-09   3.20E-10   2.11E-09   5.78E-10   9.94E-10   2.51E-09   2.33E-09   4.32E-09
   80000.   1.61E-09   3.37E-10   2.21E-09   6.07E-10   [illegible]   2.63E-09   2.45E-09   4.54E-09
   90000.   1.67E-09   3.50E-10   2.30E-09   6.31E-10   1.08E-09   2.73E-09   2.54E-09   4.71E-09
  100000.   1.72E-09   3.60E-10   2.37E-09   6.49E-10   1.12E-09   2.82E-09   2.62E-09   4.85E-09
  200000.   4.41E-09   9.22E-10   6.06E-09   1.66E-09   2.86E-09   7.21E-09   6.71E-09   1.24E-08
  300000.   4.35E-09   9.09E-10   5.98E-09   1.64E-09   2.82E-09   7.11E-09   6.61E-09   1.23E-08
  400000.   4.32E-09   9.04E-10   5.94E-09   1.63E-09   2.80E-09   7.07E-09   6.57E-09   1.22E-08
  500000.   4.30E-09   9.00E-10   5.91E-09   1.62E-09   2.79E-09   7.04E-09   6.54E-09   1.21E-08
  600000.   4.28E-09   8.96E-10   5.89E-09   1.62E-09   2.78E-09   7.01E-09   6.51E-09   1.21E-08
  700000.   4.26E-09   8.92E-10   5.86E-09   1.61E-09   2.77E-09   6.98E-09   6.48E-09   1.20E-08
  800000.   4.25E-09   8.89E-10   5.84E-09   1.60E-09   2.76E-09   6.95E-09   6.46E-09   1.20E-08
  900000.   4.23E-09   8.85E-10   5.82E-09   1.60E-09   2.75E-09   6.93E-09   6.44E-09   1.19E-08
 1000000.   4.22E-09   8.82E-10   5.80E-09   1.59E-09   2.74E-09   6.90E-09   6.42E-09   1.19E-08
```

APPENDIX F 2. Output (d)

```
** AVERAGE ANNUAL NONSPECIFIC DOSE TO POPULATION, MANIM, IN MANREMS/YEAR

NONSPECIFIC ... NUCLIDE=   I-129  K=  2

     TIME   TOT BODY   GI TRACT   GONADS     LIVER      LUNGS      MARROW     BONE       THYROID
       0.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
       5.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
      10.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
      15.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
      20.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
      25.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
      30.   0.0        0.C        0.0        0.0        0.0        0.0        0.0        0.0
      40.   1.19E-11   1.55E-11   1.19E-11   4.49E-12   0.0             5.22E-12   5.22E-12   8.25E-09
      50.   1.29E-11   1.74E-11   1.29E-11   5.04E-12   0.0             5.86E-12   5.86E-12   9.27E-09
      60.   1.43E-11   1.92E-11   1.43E-11   5.56E-12   0.0             6.47E-12   6.47E-12   1.02E-08
      70.   1.56E-11   2.09E-11   1.56E-11   6.08E-12   0.0             7.05E-12   7.05E-12   1.11E-08
      80.   1.68E-11   2.26E-11   1.68E-11   6.55E-12   0.0             7.62E-12   7.62E-12   1.21E-08
      90.   1.81E-11   2.43E-11   1.81E-11   7.04E-12   0.0             8.19E-12   8.19E-12   1.29E-08
     100.   1.93E-11   2.60E-11   1.93E-11   7.52E-12   0.0             8.75E-12   8.75E-12   1.38E-08
     200.   3.50E-11   4.70E-11   3.50E-11   1.36E-11   0.0             1.58E-11   1.58E-11   2.50E-08
     300.   4.90E-11   6.58E-11   4.90E-11   1.91E-11   0.0             2.22E-11   2.22E-11   3.51E-08
     400.   6.21E-11   8.34E-11   6.21E-11   2.42E-11   0.0             2.81E-11   2.81E-11   4.45E-08
     500.   7.48E-11   1.01E-10   7.48E-11   2.91E-11   0.0             3.39E-11   3.39E-11   5.36E-08
     600.   8.73E-11   1.17E-10   8.73E-11   3.40E-11   0.0             3.95E-11   3.95E-11   6.25E-08
     700.   9.97E-11   1.34E-10   9.97E-11   3.88E-11   0.0             4.51E-11   4.51E-11   7.14E-08
     800.   1.12E-10   1.50E-10   1.12E-10   4.36E-11   0.0             5.07E-11   5.07E-11   8.01E-08
     900.   1.24E-10   1.67E-10   1.24E-10   4.83E-11   0.0             5.62E-11   5.62E-11   8.89E-08
    1000.   1.36E-10   1.83E-10   1.36E-10   5.31E-11   0.0             6.17E-11   6.17E-11   9.76E-08
    2000.   2.91E-10   3.91E-10   2.91E-10   1.13E-10   0.0             1.32E-10   1.32E-10   2.09E-07
    3000.   4.26E-10   5.72E-10   4.26E-10   1.66E-10   0.0             1.93E-10   1.93E-10   3.08E-07
    4000.   5.49E-10   7.38E-10   5.49E-10   2.14E-10   0.0             2.49E-10   2.49E-10   3.93E-07
    5000.   6.67E-10   8.96E-10   6.67E-10   2.60E-10   0.0             3.02E-10   3.02E-10   4.77E-07
    6000.   8.40E-10   1.13E-09   8.40E-10   3.27E-10   0.0             3.81E-10   3.81E-10   6.02E-07
    7000.   1.58E-09   2.12E-09   1.58E-09   6.15E-10   0.0             7.16E-10   7.16E-10   1.13E-06
    8000.   5.83E-09   7.83E-09   5.83E-09   2.27E-09   0.0             2.64E-09   2.64E-09   4.17E-06
    9000.   1.97E-08   2.65E-08   1.97E-08   7.68E-09   0.0             8.93E-09   8.93E-09   1.41E-05
   10000.   4.16E-08   5.59E-08   4.16E-08   1.62E-08   0.0             1.88E-08   1.88E-08   2.98E-05
   20000.   2.28E-07   3.06E-07   2.28E-07   8.88E-08   0.0             1.03E-07   1.03E-07   1.63E-04
   30000.   5.57E-07   7.48E-07   5.57E-07   2.17E-07   0.0             2.52E-07   2.52E-07   3.99E-04
   40000.   3.90E-06   5.25E-06   3.90E-06   1.52E-06   0.0             1.77E-06   1.77E-06   2.80E-03
   50000.   6.54E-06   8.79E-06   6.54E-06   2.55E-06   0.0             2.96E-06   2.96E-06   4.69E-03
   60000.   7.64E-06   1.03E-05   7.64E-06   2.97E-06   0.0             3.46E-06   3.46E-06   5.47E-03
   70000.   8.11E-06   1.09E-05   8.11E-06   3.16E-06   0.0             3.67E-06   3.67E-06   5.81E-03
   80000.   8.32E-06   1.12E-05   8.32E-06   3.24E-06   0.0             3.77E-06   3.77E-06   5.96E-03
   90000.   8.44E-06   1.13E-05   8.44E-06   3.29E-06   0.0             3.82E-06   3.82E-06   6.04E-03
  100000.   8.51E-06   1.14E-05   8.51E-06   3.31E-06   0.0             3.85E-06   3.85E-06   6.09E-03
  200000.   2.54E-06   3.41E-06   2.54E-06   9.89E-07   0.0             1.15E-06   1.15E-06   1.82E-03
  300000.   3.81E-05   5.12E-05   3.81E-05   1.48E-05   0.0             1.73E-05   1.73E-05   2.73E-02
  400000.   4.16E-05   5.58E-05   4.16E-05   1.62E-05   0.0             1.88E-05   1.88E-05   2.98E-02
  500000.   4.16E-05   5.59E-05   4.16E-05   1.62E-05   0.0             1.88E-05   1.88E-05   2.98E-02
  600000.   4.14E-05   5.56E-05   4.14E-05   1.61E-05   0.0             1.87E-05   1.87E-05   2.96E-02
  700000.   4.12E-05   5.54E-05   4.12E-05   1.61E-05   0.0             1.87E-05   1.87E-05   2.95E-02
  800000.   4.11E-05   5.52E-05   4.11E-05   1.60E-05   0.0             1.86E-05   1.85E-05   2.94E-02
  900000.   4.09E-05   5.50E-05   4.09E-05   1.59E-05   0.0             1.85E-05   1.85E-03   2.93E-02
 1000000.   4.08E-05   5.48E-05   4.08E-05   1.59E-05   0.0             1.85E-05   1.85E-05   2.92E-02
```

APPENDIX F 2. Output (e)

```
** AVERAGE ANNUAL LOCAL DOSE TO INDIVIDUAL, MAN2LF FOR JF=1 TO 4, MAN2L FOR TOTAL, IN MILLIREMS/YEAR

   TOTAL FOR ALL NUCLIDES                                             TOT BODY

ZONE= 1                                                                     ZONE= 2

            JF=1       JF=2       JF=3       JF=4                                   JF=1       JF=2       JF=3       JF=4
  TIME      AIR        GROUND     SURFACE    GROUND     TOTAL          TIME       AIR        GROUND     SURFACE    GROUND     TOTAL
                       SURFACE    WATER      WATER                                           SURFACE    WATER      WATER
      0.  0.0        0.0        0.0        0.0        0.0               0.  0.0        0.0        0.0        0.0        0.0
      5.  0.0        0.0        0.0        0.0        0.0               5.  0.0        0.0        0.0        0.0        0.0
     10.  0.0        0.0        0.0        0.0        0.0              10.  0.0        0.0        0.0        0.0        0.0
     15.  0.0        0.0        0.0        0.0        0.0              15.  0.0        0.0        0.0        0.0        0.0
     20.  0.0        0.0        0.0        0.0        0.0              20.  0.0        0.0        0.0        0.0        0.0
     25.  0.0        0.0        0.0        0.0        0.0              25.  0.0        0.0        0.0        0.0        0.0
     30.  0.0        0.0        0.0        0.0        0.0              30.  0.0        0.0        0.0        0.0        0.0
     40.  4.46E-04   3.95E-13   0.0        0.0        4.46E-04         40.  4.25E-06   6.69E-15   1.62E-04   0.0        1.66E-04
     50.  4.98E-04   7.50E-13   0.0        0.0        4.98E-04         50.  5.83E-06   1.34E-14   2.55E-04   0.0        2.60E-04
     60.  5.11E-04   1.19E-12   0.0        0.0        5.11E-04         60.  6.60E-06   2.01E-14   3.03E-04   0.0        3.10E-04
     70.  4.96E-04   1.58E-12   0.0        0.0        4.96E-04         70.  6.77E-06   2.68E-14   3.19E-04   0.0        3.26E-04
     80.  4.62E-04   1.98E-12   0.0        0.0        4.62E-04         80.  6.55E-06   3.36E-14   3.14E-04   0.0        3.20E-04
     90.  4.17E-04   2.38E-12   0.0        0.0        4.17E-04         90.  6.07E-06   4.03E-14   2.94E-04   0.0        3.00E-04
    100.  3.67E-04   2.78E-12   0.0        0.0        3.67E-04        100.  5.45E-06   4.71E-14   2.66E-04   0.0        2.71E-04
    200.  3.79E-04   6.87E-12   0.0        0.0        3.79E-04        200.  6.36E-06   1.16E-13   3.04E-04   0.0        3.10E-04
    300.  4.55E-05   1.15E-11   0.0        0.0        4.55E-05        300.  7.43E-07   1.95E-13   3.76E-05   0.0        3.83E-05
    400.  5.42E-06   1.74E-11   0.0        0.0        5.42E-06        400.  8.93E-08   2.94E-13   4.53E-06   0.0        4.62E-06
    500.  6.91E-07   2.52E-11   0.0        0.0        6.91E-07        500.  1.19E-08   4.27E-13   5.82E-07   0.0        5.94E-07
    600.  8.30E-08   3.59E-11   0.0        0.0        8.30E-08        600.  1.38E-09   6.08E-13   7.03E-08   0.0        7.17E-08
    700.  8.52E-09   5.02E-11   0.0        0.0        8.57E-09        700.  1.49E-10   8.50E-13   7.61E-09   0.0        7.76E-09
    800.  9.61E-10   6.87E-11   0.0        0.0        1.03E-09        800.  1.61E-11   1.16E-12   8.72E-10   0.0        8.90E-10
    900.  2.38E-10   9.22E-11   0.0        0.0        3.30E-10        900.  3.98E-12   1.56E-12   2.84E-10   0.0        2.89E-10
   1000.  2.38E-10   1.21E-10   0.0        0.0        3.60E-10       1000.  3.98E-12   2.05E-12   3.19E-10   0.0        3.25E-10
   2000.  1.32E-09   5.55E-10   0.0        0.0        1.87E-09       2000.  2.22E-11   9.41E-12   1.80E-09   0.0        1.83E-09
   3000.  4.79E-09   1.86E-09   0.0        0.0        6.65E-09       3000.  8.08E-11   3.19E-11   6.54E-09   5.80E-31   6.65E-09
   4000.  1.10E-08   4.18E-09   0.0        0.0        1.52E-08       4000.  1.87E-10   7.07E-11   1.51E-08   1.04E-20   1.53E-08
   5000.  2.03E-08   7.58E-09   0.0        0.0        2.79E-08       5000.  3.43E-10   1.28E-10   2.77E-08   1.28E-15   2.82E-08
   6000.  3.25E-08   1.21E-08   0.0        0.0        4.46E-08       6000.  5.50E-10   2.05E-10   4.45E-08   3.46E-13   4.52E-08
   7000.  4.77E-08   1.77E-08   0.0        0.0        6.54E-08       7000.  8.08E-10   3.00E-10   6.54E-08   3.62E-12   6.65E-08
   8000.  6.61E-08   2.44E-08   0.0        0.0        9.05E-08       8000.  1.12E-09   4.14E-10   9.07E-08   2.39E-11   9.22E-08
   9000.  8.73E-08   3.22E-08   0.0        0.0        1.19E-07       9000.  1.48E-09   5.48E-10   1.20E-07   8.11E-11   1.23E-07
  10000.  1.11E-07   4.10E-08   0.0        0.0        1.52E-07      10000.  1.88E-09   6.95E-10   1.55E-07   1.33E-10   1.57E-07
  20000.  3.93E-07   1.44E-07   0.0        0.0        5.37E-07      20000.  6.65E-09   2.45E-09   5.41E-07   1.07E-11   5.50E-07
  30000.  9.32E-07   3.42E-07   0.0        0.0        1.27E-06      30000.  1.58E-08   5.79E-09   1.29E-06   1.34E-10   1.31E-06
  40000.  1.55E-06   5.66E-07   0.0        0.0        2.11E-06      40000.  2.62E-08   9.59E-09   2.14E-06   1.34E-10   2.18E-06
  50000.  2.16E-06   7.89E-07   0.0        0.0        2.94E-06      50000.  3.65E-08   1.34E-08   2.98E-06   1.34E-10   3.03E-06
  60000.  2.73E-06   1.00E-06   0.0        0.0        3.73E-06      60000.  4.63E-08   1.69E-08   3.78E-06   1.34E-10   3.84E-06
  70000.  3.25E-06   1.19E-06   0.0        0.0        4.44E-06      70000.  5.51E-08   2.02E-08   4.50E-06   1.34E-10   4.58E-06
  80000.  3.72E-06   1.36E-06   0.0        0.0        5.08E-06      80000.  6.30E-08   2.31E-08   5.14E-06   1.34E-10   5.23E-06
  90000.  4.13E-06   1.51E-06   0.0        0.0        5.64E-06      90000.  6.99E-08   2.56E-08   5.70E-06   1.34E-10   5.80E-06
 100000.  4.48E-06   1.64E-06   0.0        0.0        6.12E-06     100000.  7.59E-08   2.78E-08   6.19E-06   1.34E-10   6.29E-06
 200000.  1.28E-05   4.70E-06   0.0        0.0        1.75E-05     200000.  2.18E-07   7.97E-08   1.76E-05   1.46E-12   1.79E-05
 300000.  1.31E-05   4.80E-06   0.0        0.0        1.79E-05     300000.  2.22E-07   8.14E-08   1.81E-05   1.45E-10   1.84E-05
 400000.  1.13E-05   4.16E-06   0.0        0.0        1.55E-05     400000.  1.92E-07   7.04E-08   1.57E-05   1.45E-10   1.60E-05
 500000.  9.14E-06   3.35E-06   0.0        0.0        1.25E-05     500000.  1.55E-07   5.67E-08   1.27E-05   1.44E-10   1.29E-05
 600000.  7.16E-06   2.62E-06   0.0        0.0        9.78E-06     600000.  1.21E-07   4.44E-08   9.96E-06   1.43E-10   1.01E-05
 700000.  5.54E-06   2.03E-06   0.0        0.0        7.57E-06     700000.  9.39E-08   3.44E-08   7.74E-06   1.43E-10   7.87E-06
 800000.  4.26E-06   1.56E-06   0.0        0.0        5.82E-06     800000.  7.22E-08   2.65E-08   5.99E-06   1.42E-10   6.08E-06
 900000.  3.28E-06   1.21E-06   0.0        0.0        4.49E-06     900000.  5.56E-08   2.04E-08   4.65E-06   1.41E-10   4.72E-06
1000000.  2.54E-06   9.32E-07   0.0        0.0        3.47E-06    1000000.  4.30E-08   1.58E-08   3.62E-06   1.41E-10   3.68E-06
```

APPENDIX F 2. Output (f)

```
              AVERAGE ANNUAL LOCAL DOSE TO INDIVIDUAL, MANIL, IN ZONE 1, IN MILLIREMS/YEAR

                                         1000. YEARS#
-----------------------------------------------------------------------------------------------
 K  NUCLIDE   TOT BODY  GI TRACT   GONADS     LIVER      LUNGS     MARROW      BONE    THYROID
-----------------------------------------------------------------------------------------------
 1     SR-90  6.36E-12  1.27E-13  6.36E-12  0.0        3.47E-11  9.54E-11  9.54E-11  0.0
 2     I-129  3.79E-11  7.92E-12  5.21E-11  1.43E-11   2.47E-11  6.70E-11  5.76E-11  1.08E-10
-----------------------------------------------------------------------------------------------
   SUM TOTAL  4.42E-11  9.05E-12  5.84E-11  1.43E-11   5.93E-11  1.57E-10  1.53E-10  1.08E-10
-----------------------------------------------------------------------------------------------
 3    PB-210  3.15E-10  3.41E-11  3.02E-10  2.15E-09   4.36E-08  2.26E-08  2.26E-08  7.01E-11
-----------------------------------------------------------------------------------------------
   SUB TOTAL  3.15E-10  3.41E-11  3.02E-10  2.15E-09   4.36E-08  2.26E-08  2.26E-08  7.01E-11
-----------------------------------------------------------------------------------------------
       TOTAL  3.59E-10  4.21E-11  3.60E-10  2.16E-09   4.36E-08  2.28E-08  2.27E-08  1.78E-10
-----------------------------------------------------------------------------------------------
#TIME SINCE START OF REPOSITORY OPERATIONS.
```

```
              AVERAGE ANNUAL NONSPECIFIC DOSE TO POPULATION, MANIN, IN MANREMS/YEAR

                                         1000. YEARS#
-----------------------------------------------------------------------------------------------
 K  NUCLIDE   TOT BODY  GI TRACT   GONADS     LIVER      LUNGS     MARROW      BONE    THYROID
-----------------------------------------------------------------------------------------------
 1     SR-90  5.74E-11  1.69E-11  5.74E-11  0.0        0.0       2.87E-09  2.87E-09  0.0
 2     I-129  1.36E-10  1.83E-10  1.36E-10  5.31E-11   0.0       6.17E-11  6.17E-11  9.76E-08
-----------------------------------------------------------------------------------------------
   SUM TOTAL  1.94E-10  2.00E-10  1.94E-10  5.31E-11   0.0       2.93E-09  2.93E-09  9.76E-08
-----------------------------------------------------------------------------------------------
 3    PB-210  6.48E-09  1.23E-10  6.48E-09  5.98E-08   0.0       6.36E-07  6.36E-07  0.0
-----------------------------------------------------------------------------------------------
   SUB TOTAL  6.48E-09  1.23E-10  6.48E-09  5.98E-08   0.0       6.36E-07  6.36E-07  0.0
-----------------------------------------------------------------------------------------------
       TOTAL  6.68E-09  3.23E-10  6.68E-09  5.98E-08   0.0       6.39E-07  6.39E-07  9.76E-08
-----------------------------------------------------------------------------------------------
#TIME SINCE START OF REPOSITORY OPERATIONS.
```

APPENDIX G

PROGRAMMER'S NOTES

Variables

The variables used and their definitions are presented in the list of nomenclature in the front pages of this volume.

"Index" File Structure

"Index" is an unformatted temporary file allocated to logical unit 1. Index holds a maximum of 260 records, each 400 bytes in length. Index is calculated for each nuclide and zone.

Subprogram Usage

SUBROUTINE FAULT - determines release probability transfer coefficient. Also, by use of time dependent component factors, the subroutine can modify the nuclide inventory at risk.

FUNCTION RLEACH - calculates amount of nuclide leached into the ground water preliminary environmental input receptor. The function is called by SUBROUTINE FAULT when a leach incident is involved.

SUBROUTINE TRINP - determines transport-to-environment transfer coefficient, accounting for decay and other processes such as delay in ground water transport.

FUNCTION CRATIO - determines concentration ratio in ground water at discharge point compared to release point. This ground water transport function is called by SUBROUTINE TRINP.

SUBROUTINE TRMAN - determines environment-to-man transfer coefficient for dose to man via all pathways from environmental concentrations.

Dimensioning

Some exchanges of dimensioning can be used for special cases without increasing storage requirements. For example, 9 Release Model events, each with 9 component factors represent 81 storage combinations

(= 9 x 9). If release is described by an involved function representing dynamic repository simulation, AMRAW can be dimensioned by other combinations such as one release event with up to 81 component factors if needed. The number of geographic zones, presently dimensioned at 8 is limited to 9 because of programming for the variable "NPRINT" which controls output options.

Multiple Cases

AMRAW-A has provisions for running more than one case, per submission. This can be: 1) more than one set of conditions for a waste management phase such as terminal storage, or 2) more than one phase, such as repository operations and terminal storage. A full set of input data is read in for each case.

Modification for Running on CDC System

AMRAW, written in FORTRAN IV, was developed with implementation on an IBM 360 system. Some changes are necessary for operation on a CDC system. The following programming features in AMRAW-A, used successfully on the IBM system, produce problems on a CDC 6400:

1. Three quadruply dimensioned arrays are used: DOSFAC, MAN2LF, and VOLINT. ANSI Fortran permits up to 3 subscripts.
2. DO loop control indices are passed through common, e.g., IZ in /BTRINP/, JF and IH in /BTRMAN/, etc.
3. "Computed GOTO" drops to the next statement when out of range in FORTRAN G on the IBM, but causes a fatal error on the CDC.
4. Integers are declared as INTEGERS*2 and INTEGER*4 variables, not necessary on the CDC. The use of INTEGER*4 in AMRAW is for storing 8 characters per variable; the CDC will store 10 characters when declared as INTEGER.
5. "Direct access" read and write, used in AMRAW do not exist directly on the CDC.

EPA personnel at the Las Vegas, Neveda facility identified the above problems, incorporated changes to respond to the problems, and have run the modified version on a CDC 6400 computer. The changes, listed in correspondence with the problems, are as follows:

1. Change the 3 quadruply dimensioned arrays into triply dimensioned arrays through the addition of new variables.
2. Change the way the control indices are passed through common.
3. Introduce an extra IF test before the computed GOTO to achieve the same effect as in FORTRAN G.
4. Change INTERGER*2 and INTEGER*4 to INTEGER.
5. Replace the IBM direct access file writes and reads by calls to subroutines which manage ACTUAL KEY files.

Also, to reduce the large memory requirements, put the arrays resulting from MAN2LF into blank common. The way blank common is allocated on the available CDC 6400 system allows the LOADER to use the region which will become blank common during the loading process.

APPENDIX H

AMRAW-A LISTING

1. **Main Program**

   MAIN

2. **Sub-programs**

   FAULT - Release Model

   RLEACH - Leach rate calculations

   TRINP - Transport-to-Environment part of Environmental Model

   CRATIO - Ground water transport calculations

   TRMAN - Environment-to-Man part of Environmental Model

Discussion of changes needed for running on a CDC 6400 computer instead of IBM is presented in Appendix G (Programmer's Notes).

APPENDIX H   Main Program

```
FORTRAN IV G LEVEL  21                  MAIN                DATE = 78098          22/30/04

C     AMRAW: ASSESSMENT METHOD FOR RADIOACTIVE WASTE.
C     A CODE DEVELOPED BY UNIVERSITY OF NEW MEXICO UNDER EPA CONTRACT #68-01-3256
C     THIS LISTING IS AMRAW-A, CALCULATION THROUGH DOSE RATE.
C     PRINCIPLE INVESTIGATOR: S.E.LOGAN, DECEMBER,1977.
      IMPLICIT INTEGER*2 (I-N)
      DOUBLE PRECISION NUCNAM(25),ORGNAM(8),TITLE(10,3),
     *HEAD(4,6),HEAD1(4),AIZ
      REAL AA1(4,9),ADJ1(4,4,8),ADJ2(4,4,8),BIOFAC(25,4,6),CP(4,9,4)
      REAL DC1,DISPN(4,8),DRC,DOSFAC(25,4,2,8),EDC(25,4,8)
      REAL MAN2LF(50,8,8,4),MAN2L(50,8,8),MAN2NF(50,8,4),MAN2N(50,8)
      REAL ELEM(15),MAN1L(50,8),MAN1N(50,8),PROBB(4,9,4),R1J(4,50)
      REAL R2(4,50,8),R2TOT(4,50,8),REMOV(4,8),RKD(25)
      REAL SPACT,TIME(50),TP(4,9,4),VOLINT(4,2,6,8),X,XX(15)
      REAL ZONALD(4,8),RELOUT(9),XL(8),YW(8),YY(8)
      REAL ZONDEP(8),GNDEP(50,8),AREAW(8)
      INTEGER*2 IFLAG(4,9,4),IFLAGE(4,2,6)
      INTEGER*2 JJ(4,9),NJ(4),NJJ(4,9),NSP(6),IZONE(10)
      INTEGER*4 NPRINT,CHECK(19),JN(9),VAR(5),IN,IP,IE
      DATA VAR/'(F10','.0,I','5,1P','9E1','2.2)'/
      DATA HEAD1/' NONE',' JF= 2',' JF= 3',' JF= 253'/
      DATA AIZ/'IZ='/
      DATA JN/'1E1','2E1','3E1','4E1','5E1','6E1','7E1','8E1','9E1'/
      DATA HEAD/'        ','   DATA ','INPUT   ','        ',
     2'      REL','EASE TO ','ENVIRONM','ENT     ',
     3'    LOCA','L DOSE T','O INDIVI','DUAL    ',
     4' NONSPEC','IFIC DOS','E TO POP','ULATION ',
     5'     TOTA','L DOSE B','Y RECEPT','ORS     ',
     6'       DO','SE SUMMA','RY TABLE','S       '/
      COMMON/BFAULT/ PROBB,AA1,TP,CP,IFLAG
      COMMON/BLEACH/ DC1(25),DRC(25),X(25,50),FS,VS,SPACT(25),CINV
      COMMON/FOLEA/ CFA1,XR,DELTIM,I1
      COMMON/BTRINP/ Y2,Y3,I2,IFDIVW
      COMMON/CTRINP/ CRMIN,DFMIN
      COMMON/BTRMAN/ BIOFAC,VOLINT,DOSFAC,NSP,IFLAGE,JF,IM,DELTE
      COMMON/BCRATO/ RKD,CONC1,TIME,VX,PORE,AL,AT,NT,BULKD,YW,ITR,NT,
     1ITE,K,GNODIS,YY
      COMMON/FCRATO/DELTL
      DEFINE FILE 1(260,400,U,INDEX)
      IN=5
      IE=6
      IP=4
      READ(IN,801)NCASE
      DO 9999 KASE=1,NCASE
      WRITE(IP,802)KASE
C********************************* READ IN DATA AND INITIALIZE CASE **
C*********************** THE TITLE MUST HAVE THREE LINES ***************
      READ(IN,803)TITLE
      IF(IP.NE.IE)WRITE(IE,836)TITLE,NCASE,(HEAD(I,1),I=1,4)
      READ(IN,801)ND,NK,NT,IW,ITRS,ITRE,NZ,NINT,NPRINT,IFDIVW
      IF(IW.EQ.3.AND.ITRE.GE.NT)GO TO 9998
C********************** SET ORGAN, ZONE, AND NPRINT VALUES **********
      IORGS=IABS(MOD(NPRINT,10))
      IORGE=IORGS-1
```

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FORTRAN IV G LEVEL  21                 MAIN                  DATE = 78096           22/35/04

 0040              IF(IORGS.EQ.0)IORGE=NIHT
 0041              IF(IORGS.EQ.0)IORGS=1
 0042              IF(IORGS.GT.NIHT)GO TO 9997
 0043              NPRINT=NPRINT/10
 0044              ISTART=IABS(MOD(NPRINT,10))
 0045              ISTOP=ISTART-1
 0046              IF(ISTART.EQ.0)ISTOP=MZ
 0047              IF(ISTART.EQ.0)ISTART=1
 0048              IF(ISTART.GT.MZ)GO TO 9996
 0049              NPRINT=NPRINT/10
 0050              IF(KASE.GT.1)GO TO 5
          C************************ READ IN CUTOFF VALUES ************************
 0051              READ(IN,806)R1JMIN,A2MIN,R2MIN,RKDMAX,CRMIN,DFMIN
 0052              READ(IN,806)(TIME(I),I=1,NT)
 J053              READ(IN,807)(ELEM(ID),ID=1,ND)
 0054              READ(IN,806)TFUEL
 0055              READ(IN,806)(XX(ID),ID=1,ND)
 0056              DO 20 K=1,NK
 0057              READ(IN,808)NUCNAM(K),(X(K,IT),IT=1,7)
 0058              IF(NT.GE.8)READ(IN,809)(X(K,IT),IT=8,NT)
 0059           20 CONTINUE
 0060              READ(IN,845,ERR=9998,END=9998)CHECK,ICHCK
 0061              IF(ICHCK.NE.1)GO TO 9998
 0062              WRITE(IE,848)CHECK,ICHCK
 0063              READ(IN,806)(SPACT(K),K=1,NK)
 0064              READ(IN,806)(DC1(K),K=1,NK)
 0065              READ(IN,806)(DRC(K),K=1,NK)
 0066              READ(IN,806)(((ADJ1(JF,JFA,IZ),ADJ2(JF,JFA,IZ),JFA=1,4),JF=1,4),
                  *IZ=1,MZ)
 0067              READ(IN,806)((DISPN(JF,IZ),IZ=1,MZ),JF=1,4)
 0068              READ(IN,806)((ZONALD(JF,IZ),IZ=1,MZ),JF=1,4)
 0069              READ(IN,806)(ZONDEP(IZ),IZ=1,MZ)
 0070              READ(IN,806)(AREAW(IZ),IZ=1,MZ)
 0071              READ(IN,806)(RKD(K),K=1,NK)
 0072              READ(IN,845,ERR=9998,END=9998)CHECK,ICHCK
 0073              IF(ICHCK.NE.2)GO TO 9998
 0074              WRITE(IE,848)CHECK,ICHCK
 0075              READ(IN,801)(NSP(JF),JF=1,4)
 0076              DO 30 IZ=1,MZ
 0077              DO 30 JF=1,4
 0078              NS=NSP(JF)
 0079           30 READ(IN,806)((VOLINT(JF,MODE,I,IZ),I=1,NS),MODE=1,2)
 0080              DO 40 K=1,NK
 0081              DO 40 NS=1,6
 0082           40 BIOFAC(K,1,NS)=1.
 0083              DO 50 K=1,NK
 0084              DO 50 JF=2,4
 0085              NS=NSP(JF)
 0086           50 READ(IN,806)(BIOFAC(K,JF,I),I=1,NS)
 0087              READ(IN,845,ERR=9998,END=9998)CHECK,ICHCK
 0088              IF(ICHCK.NE.3)GO TO 9998
 0089              WRITE(IE,848)CHECK,ICHCK
 0090              READ(IN,803)(ORGNAM(I),I=1,NIHT)
 0091                READ(IN,806)((((DOBFAC(K,JF,MODE,IH),IH=1,NIHT),MODE=1,2),JF=1,4),
                    *K=1,NK)
 0092              5 CONTINUE
 0093                READ(IN,845,ERR=9998,END=9998)CHECK,ICHCK
 0094                IF(ICHCK.NE.4)GO TO 9998
 0095                WRITE(IE,848)CHECK,ICHCK
           C************** JJ(JF,I) SPECIFIES A PARTICULAR RELEASE EVENT CUTSET. **
           C******************* NJ(JF) =# OF RELEASE CUTSETS ASSOCIATED WITH JF. **
           C********* NJJ(JF,I) =# OF PROBABILITIES ASSOCIATED WITH EACH CUTSET. **
 0096           1000 ISECT=1
 0097                WRITE(IP,836)TITLE,ISECT,(HEAD(I,ISECT),I=1,4)
 0098                WRITE(IP,805)
 0099                DO 1030 JF=1,4
 0100                READ(IN,801)NJ(JF)
 0101                NJF=NJ(JF)
 0102                IF(NJF.EQ.0)GO TO 1030
 0103                DO 1020 I=1,NJF
 0104                READ(IN,801)JJ(JF,I),NJJ(JF,I)
 0105                J=JJ(JF,I)
 0106                NJJJ=NJJ(JF,I)
 0107                READ(IN,806)AA1(JF,J)
 0108                DO 1020 K=1,NJJJ
 0109                READ(IN,810)PROBB(JF,J,K),IFLAG(JF,J,K),TP(JF,J,K),CP(JF,J,K)
 0110                IF(K.EQ.1)WRITE(IP,811)JF,NJF,J,NJJJ,AA1(JF,J),PROBB(JF,J,1),
                    *IFLAG(JF,J,1),TP(JF,J,1),CP(JF,J,1)
 0111                IF(K.GT.1)WRITE(IP,812)PROBB(JF,J,K),IFLAG(JF,J,K),TP(JF,J,K),
                    *CP(JF,J,K)
 0112           1020 CONTINUE
 0113           1030 CONTINUE
 0114                IF(KASE.GT.1)GO TO 6
 0115                DO 1060 JF=1,4
 0116                J=NSP(JF)
 0117           1060 READ(IN,801)(((IFLAGE(JF,MODE,I),I=1,J),MODE=1,2)
 0118                READ(IN,806)VX,PORE,AL,AT,HT,BULKD,FS,VS,(XL(I),I=1,NZ),
                    1(VW(I),I=1,NZ),(VV(I),I=1,NZ),
                    2CINV,CFA1
 0119                READ(IN,845,ERR=9998,END=9998)CHECK,ICHCK
 0120                IF(ICHCK.NE.5) GO TO 9998
 0121                WRITE(IE,848)CHECK,ICHCK
           C******** READ EDC FLAG 1=DEFAULT,2=JF READ,3=JF READ,4=READ JF=2&3 ****
 0122                READ(IN,801)ISECT
 0123                I=ISECT
 0124                DO 1130 K=1,NK
 0125                DO 1130 IZ=1,NZ
 0126                EDC(K,1,IZ)=50.0
 0127                EDC(K,4,IZ)=0.0
 0128                GO TO(1110,1120,1110,1130),I
 0129           1110 EDC(K,2,IZ)=2.30*10.0**(-5)
 0130                GO TO(1120,1130,1130,1130),I
 0131           1120 EDC(K,3,IZ)=2.30*10.0**(-5)
 0132           1130 CONTINUE
 0133                GO TO(1210,1160,1160,1140),I
 0134           1140 DO 1150 I=2,3
```

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FORTRAN IV G LEVEL  21                MAIN              DATE = 78096           22/35/54

          1150 READ(IN,806)((EDC(K,1,IZ),IZ=1,NZ),K=1,NK)
               GO TO 1210
          1160 READ(IN,806)((EDC(K,1,IZ),IZ=1,NZ),K=1,NK)
          1210 READ(IN,845,ERR=9998,END=9998)CHECK,ICHCK
               IF(ICHCK.NE.6) GO TO 9998
               WRITE(IE,848)CHECK,ICHCK
         C************************** READ SECTION 6 INPUT TO STMT 1310 *********
         C************************************ IZONM = # OF TABLES WANTED **
               READ(IN,801)IZONM
               IF(IZONM.EQ.0)GO TO 1310
         C******* IZONE = ZONES TO DO. IZONE = 10 MEANS NONSPECIFIC *******
               READ(IN,801)(IZONE(I),I=1,IZONM)
         C*** ITSUMY=INITIAL TIME. ITSUMJ=TIME CHANGE. KSUB=K FOR SUBTOTAL **
               READ(IN,801)ITSUMY,ITSUMJ,KSUB
          1310 LPRINT=NK/10+1
               IF(NK.EQ.NK/10*10)LPRINT=LPRINT-1
             6 CONTINUE
               IF(NPRINT.EQ.0.OR.NPRINT.EQ.5)GO TO 1500
               GO TO 2000
         C**************************************** OUTPUT SELECTED INPUT DATA **
          1500 WRITE(IP,813)TFUEL
               WRITE(IP,814)(ELEM(ID),XX(ID),ID=1,ND)
               M1=1
               M10=10
               WRITE(IP,815)
               DO 1550 I=1,LPRINT
               IF(M10.GT.NK)M10=NK
               WRITE(IP,816)(NUCNAM(K),K=M1,M10)
               DO 1540 IT=1,NT
          1540 WRITE(IP,817)TIME(IT),(X(K,IT),K=M1,M10)
               WRITE(IP,818)(SPACT(K),K=M1,M10)
               M1=M10+1
               M10=M10+10
          1550 CONTINUE
               WRITE(IP,819)
               DO 1580 K=1,NK
          1580 WRITE(IP,820)NUCNAM(K),DC1(K),DRC(K),RKD(K)
               WRITE(IP,859) VX,PORE,BULKD,AL,AT,HT,(AIZ(I),I=1,NZ)
               WRITE(IP,870) (XL(I),I=1,NZ)
               WRITE(IP,871) (YW(I),I=1,NZ)
               WRITE(IP,872) (YY(I),I=1,NZ)
               WRITE(IP,873) FS,VS,CINV,CFAI
               WRITE(IP,821)HEAD1(ISECT)
               DO 1620 IZ=1,NZ,2
               IZP1=IZ+1
               IF (IZ.EQ.5)WRITE(IP,844)
               WRITE(IP,822)IZ,IZP1
               DO 1620 K=1,NK
          1620 WRITE(IP,823)NUCNAM(K),((EDC(K,JF,I),JF=1,4),I=IZ,IZP1)
               WRITE(IP,824)
               DO 1660 IZ=1,NZ,2
               IZP1=IZ+1
          1660 WRITE(IP,822)IZ,IZP1,((DISPN(JF,I),JF=1,4),I=IZ,IZP1)
```

```
 0183              WRITE(IP,849)
 0184              DO 1700 IZ=1,NZ,2
 0185              IZP1=IZ+1
 0186        1700  WRITE(IP,822)IZ,IZP1,((ZONALO(JF,I),JF=1,4),I=IZ,IZP1)
 0187              WRITE(IP,850) (AIZ,I,I=1,NZ)
 0188              WRITE(IP,880) (ZONDEP(I),I=1,NZ)
 0189              WRITE(IP,881) (AIZ,I,I=1,NZ)
 0190              WRITE(IP,860) (AREAW(I),I=1,NZ)
 0191              WRITE(IP,825)
 0192              DO 1740 IZ=1,NZ
 0193              WRITE(IP,826)IZ
 0194              DO 1740 JF=1,4
 0195              WRITE(IP,827)JF,(ADJ1(JF,JFA,IZ),ADJ2(JF,JFA,IZ),JFA=1,4)
 0196        1740  CONTINUE
 0197              WRITE(IP,828)
 0198              DO 1780 IZ=1,NZ
 0199              IF((IZ/5)*5.EQ.IZ)WRITE(IP,844)
 0200              WRITE(IP,829)IZ
 0201              DO 1780 JF=1,4
 0202              NS=NSP(JF)
 0203              DO 1780 MODE=1,2
 0204        1780  WRITE(IP,830)JF,MODE,NS,(VOLINT(JF,MODE,I,IZ),I=1,NS)
 0205              WRITE(IP,831)
 0206              DO 1830 K=1,NK
 0207              WRITE(IP,832)NUCNAM(K)
 0208              DO 1820 JF=1,4
 0209              NS=NSP(JF)
 0210        1820  WRITE(IP,843)JF,NS,(BIOFAC(K,JF,I),I=1,NS)
 0211              IF((K/9)*9.EQ.K)WRITE(IP,844)
 0212        1830  CONTINUE
 0213              WRITE(IP,833)
 0214              DO 1870 IH=IORGS,IORGE
 0215              WRITE(IP,834)ORGNAM(IH)
 0216              DO 1860 K=1,NK
 0217        1860  WRITE(IP,835)NUCNAM(K),((DOSFAC(K,JF,MODE,IH),MODE=1,2),
                  1JF=1,4)
 0218              IF((IH/2)*2.EQ.IH)WRITE(IP,844)
 0219        1870  CONTINUE
 0220              IF(NPRINT.EQ.0)GO TO 9999
           C*************************TO STMT 2999 CONSIDER EACH BRANCH SEPARATELY **
 0221        2000  ISECT=2
 0222              WRITE(IP,836)TITLE,ISECT,(HEAD(I,ISECT),I=1,4)
 0223              IF(IW.EQ.3)DTIME=TIME(ITRE+1)-TIME(ITRE)
 0224              DO 2020 IT=1,NT
 0225              DO 2020 IH=1,NINT
 0226              MAN2H(IT,IH)=0.0
 0227              DO 2020 JF=1,4
 0228              MAN2HF(IT,IH,JF)=0.0
 0229              DO 2020 IZ=ISTART,ISTOP
 0230              MAN2LF(IT,IH,IZ,JF)=0.0
 0231        2020  MAN2L(IT,IH,IZ)=0.0
 0232              GMDOIS=1.0
           C********************TO STMT 2999 CONSIDER EACH RADIONUCLIDE *******
```

```
      DO 2999 K=1,NK
      IF(IW.EQ.3)DFAC=(1.0-(X(K,ITRE+1)/X(K,ITRE)))/DTIME
      CTR1=0.
      LINEP=4
      DO 2050 IT=1,NT
      DO 2040 IH=1,NIHT
 2040 MANIN(IT,IH)=0.0
      DO 2050 JF=1,4
      R1J(JF,IT)=0.
      DO 2050 IZ=ISTART,ISTOP
      R2(JF,IT,IZ)=0.
      R2TOT(JF,IT,IZ)=0.
 2050 GNDEP(IT,IZ)=0.0
C************* TO STMT 2500 CALCULATE ENVIRONMENTAL CONCENTRATIONS **
C********** CALCULATE RELEASE DURING EACH TIME INTERVAL ****************
C************* TO PRELIMINARY ENVIRONMENT INPUT RECEPTORS TO STMT 2140 **
      IF(NPRINT.EQ.5)WRITE(IP,847)NUCNAM(K),K
      DO 2500 ITR=ITRS,ITRE
      DELTL=TIME(ITR)-TIME(ITR-1)
      XR=X(K,ITR)
      ZAVG=((XR+X(K,ITR-1))*SPACT(K))/2.0
      DO 2120 I=1,9
 2120 RELOUT(I)=0.0
      DO 2160 JF=1,4
      NJF=NJ(JF)
      IF(NJF.EQ.0)GO TO 2160
      DO 2140 I=1,NJF
      J=JJ(JF,I)
      NJJJ=NJJ(JF,I)
      IF(CTR1.GE.1.)GO TO 2140
C********************* DETERMINE RELEASE FAULT PROB AND TRANSFER COEFF **
      CALL FAULT(TIME,PROB,A1,JF,J,NJJJ,ITR,K,CONC1)
      PRBDEL=PROB*DELTL
      IF(PRBDEL.GT.1.0) PRBDEL=1.0
      REL=PRBDEL*A1
      REL=ABS(REL)
      CTR1=CTR1+REL
      IF(REL.GT.1.)REL=1.
      RELOUT(I)=REL
      R1J(JF,ITR)=R1J(JF,ITR)+ZAVG*REL
 2140 CONTINUE
C****************** TO STMT 2160 OUTPUT RELEASE FRACTIONS BY CUTSET ***
      VAR(4)=JN(NJF)
      LINEP= LINEP+1
      IF(LINEP.GT.60.AND.NPRINT.EQ.5)WRITE(IP,852)
      IF(LINEP.GT.60)LINEP=1
      IF(NPRINT.EQ.5)WRITE(IP,VAR)TIME(ITR),JF,(RELOUT(I),I=1,NJF)
 2160 CONTINUE
C******TO STMT 2499 FOLLOW EACH RELEASE INCREMENT THROUGH ENVIRONMENT **
C*********************************** DURING SUBSEQUENT TIME INTERVALS **
      DO 2499 ITE=ITR,NT
      DELT2=TIME(ITE-1)-TIME(ITR)
      DELT3=TIME(ITE)-TIME(ITR)
```

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FORTRAN IV G LEVEL  21                    MAIN              DATE = 78096            22/35/04
 0279                DO 2210 IZ=ISTART,ISTOP
 0280                DO 2210 JF=1,4
 0281           2210 REMOV(JF,IZ)=0.
              C********** TO STMT 2220 DETERMINE TRANSFER COEFF TO ENVIRONMENT INPUT **
 0282                XEM1=X(K,ITE-1)
 0283                XE=X(K,ITE)
 0284                DO 2390 IZ=ISTART,ISTOP
 0285                DO 2280 JF=1,4
              C*************************** SET TEMPORARY VALUES FOR DELT4 AND XEM2. **
 0286                DELT4=0.
 0287                XEM2=XEM1
 0288                TRL=EDC(K,JF,IZ)
 0289                IF(JF.EQ.4.OR.ITE.EQ.ITR)GO TO 2220
 0290                XEM2=X(K,ITE-2)
 0291                DELT4=(TIME(ITE)-TIME(ITE-2))/2.
 0292           2220 CALL TRINP(DELT2,DELT3,DELT4,XR,XE,XEM1,XEM2,TRL,DECFAC,A2,
                    *XL(IZ),X(K,ITRE),DFAC,
                    *ITE,ITRE,IW,JF,RKD,RKDMAX,K)
 0293                IF(R1J(JF,ITR).LE.R1JMIN)R1J(JF,ITR)=0.0
 0294                IF(A2.LE.A2MIN)A2=0.0
 0295                IF(JF.EQ.4)GO TO 2260
 0296                IF(ITE.NE.ITR)GO TO 2270
 0297                GO TO (2230,2240,2250),JF
 0298           2230 R2(JF,ITE,IZ)=R1J(JF,ITR)*A2*ZONALO(JF,IZ)
 0299                DEP=R1J(JF,ITR)*A2*ZONDEP(IZ)
 0300                AREAG=DISPN(2,IZ)
 0301                DEPGND=DEP*AREAG
 0302                DEPWTR=DEP*AREAW(IZ)
 0303                GO TO 2280
 0304           2240 R2(JF,ITE,IZ)=R1J(JF,ITR)*A2*ZONALO(JF,IZ)+DEPGND
 0305                GO TO 2280
 0306           2250 R2(JF,ITE,IZ)=R1J(JF,ITR)*A2*ZONALO(JF,IZ)+DEPWTR
 0307                GO TO 2280
 0308           2260 R2(JF,ITE,IZ)=R1J(JF,ITR)*A2*ZONALO(JF,IZ)
 0309                GO TO 2280
 0310           2270 R2(JF,ITE,IZ)=R2(JF,ITE-1,IZ)*A2
 0311           2280 IF(R2(JF,ITE,IZ).LE.R2MIN)R2(JF,ITE,IZ)=0.0
              C**** TO STMT 2499 ADJUST ENVIPON RECEPTOR; TRANSFER FROM OTHER RECEPTORS **
 0312                DO 2330 JF=1,4
 0313                DO 2330 JFA=1,4
 0314                IF(JFA.EQ.JF.OR.ADJ1(JF,JFA,IZ).EQ.0.)GO TO 2330
 0315                DELTE=TIME(ITE)-TIME(ITE-1)
 0316                AMD=ADJ2(JF,JFA,IZ)*0.5*DELTE
 0317                IF(AMD.GT.15.)GO TO 2300
 0318                ADJ=ADJ1(JF,JFA,IZ)*(1.-EXP(-AMD))
 0319                GO TO 2310
 0320           2300 ADJ=ADJ1(JF,JFA,IZ)
 0321                IF(JF.NE.1)GO TO 2310
              C******* FOLLOWING STATEMENT IS INTEGRATED CONCENTRATION FOR RESUSPENSION **
 0322                ADJR2=ADJ*R2(JFA,ITE,IZ)*(DELTE/DISPN(JFA,IZ))
 0323                GO TO 2320
 0324           2310 ADJR2=ADJ*R2(JFA,ITE,IZ)
 0325           2320 R2(JF,ITE,IZ)=R2(JF,ITE,IZ)+ADJR2
```

```
FORTRAN IV G LEVEL  21                 MAIN               DATE = 78096           22/35/04
 0326                  IF(JF.EQ.1)GO TO 2330
 0327                  REMOV(JFA,IZ)=REMOV(JFA,IZ)+ADJR2
 0328             2330 CONTINUE
 0329                  DO 2390 JF=1,4
 0330                  IF(DISPN(JF,IZ).EQ.0.)GO TO 2390
 0331                  GO TO (2340,2350,2360,2370),JF
 0332             2340 R2CON=10.**6*R2(JF,ITE,IZ)
 0333                  GO TO 2380
 0334             2350 R2CON=10.**6*R2(JF,ITE,IZ)/DISPN(JF,IZ)
 0335                  IF(ITE.NE.ITR)GO TO 2380
 0336                  GNDEP(ITE,IZ)=R2CON
 0337                  GO TO 2380
 0338             2360 R2CON=10.**6*R2(JF,ITE,IZ)/DISPN(JF,IZ)
 0339                  GO TO 2380
 0340             2370 DISPN(JF,IZ)=GNDDIS
 0341                  IF(GNDDIS.EQ.0.)R2CON=0.
 0342                  IF(GNDDIS.EQ.0.)GO TO 2380
 0343                  R2CON=R2(JF,ITE,IZ)/DISPN(JF,IZ)
 0344             2380 R2TOT(JF,ITE,IZ)=R2TOT(JF,ITE,IZ)+R2CON
 0345             2390 CONTINUE
 0346                  DO 2499 JF=1,4
 0347                  DO 2499 IZ=ISTART,ISTOP
 0348                  R2(JF,ITE,IZ)=R2(JF,ITE,IZ)-REMOV(JF,IZ)
 0349             2499 IF(R2(JF,ITE,IZ).LT.0.)R2(JF,ITE,IZ)=0.
 0350             2500 CONTINUE
                 C******************** TO STMT 2730 CALCULATE EACH CATAGORY OF MAN DOSE **
 0351                  DO 2730 IZ=ISTART,ISTOP
 0352                  DO 2700 IH=1,NIHT
 0353                  DO 2700 ITE=1,NT
 0354             2700 MAN1L(ITE,IH)=0.0
 0355                  DO 2730 ITE=ITRS,NT
 0356                  DELTE=TIME(ITE)-TIME(ITE-1)
 0357                  DO 2720 IH=IORGS,IORGE
 0358                  DO 2720 JF=1,4
                 C************************* TRMAN, DETERMINE TRANSFER COEFF TO MAN DOSE **
 0359                  NSS=1
 0360                  CALL TRMAN(K,ITE,IZ,NSS,C)
 0361                  MAN1L(ITE,IH)=MAN1L(ITE,IH)+C*R2TOT(JF,ITE,IZ)
 0362                  MAN2LF(ITE,IH,IZ,JF)=MAN2LF(ITE,IH,IZ,JF)+C*R2TOT(JF,ITE,IZ)
 0363                  MAN2L(ITE,IH,IZ)=MAN2L(ITE,IH,IZ)+C*R2TOT(JF,ITE,IZ)
 0364                  NSS=2
 0365                  CALL TRMAN(K,ITE,IZ,NSS,C)
                 C*****APPLYING .001 FACTOR TO STMTS 2720: CONVERTS MILLIMANREM TO MANREM********
 0366                  IF(JF.NE.2)GO TO 2710
 0367                  MAN2NF(ITE,IH,JF)=MAN2NF(ITE,IH,JF)+C*GNDEP(ITE,IZ)*0.001
 0368                  MAN2N(ITE,IH)=MAN2N(ITE,IH)+C*GNDEP(ITE,IZ)*0.001
 0369                  MAN1N(ITE,IH)=MAN1N(ITE,IH)+C*GNDEP(ITE,IZ)*0.001
 0370                  GO TO 2720
 0371             2710 MAN2NF(ITE,IH,JF)=MAN2NF(ITE,IH,JF)+C*R2TOT(JF,ITE,IZ)*0.001
 0372                  MAN2N(ITE,IH)=MAN2N(ITE,IH)+C*R2TOT(JF,ITE,IZ)*0.001
 0373                  MAN1N(ITE,IH)=MAN1N(ITE,IH)+C*R2TOT(JF,ITE,IZ)*0.001
 0374             2720 CONTINUE
 0375             2730 CONTINUE
```

```
      INDEX=10*(K-1)+12
 2760 WRITE(1'INDEX)((MANIL(ITE,IH),ITE=1,MT),IH=IORGS,IORGE)
      INDEX=10*(K-1)+10
      WRITE(1'INDEX)((MANIN(ITE,IH),ITE=1,MT),IH=IORGS,IORGE)
C**************** TO STMT 2870 OUTPUT ENVIRONMENT INPUT CONCENTRATIONS **
      IF(NPRINT.EQ.6)GO TO 2999
      IF(NPRINT.EQ.2)GO TO 2840
      WRITE(IP,839)NUCNAM(K),K
      DO 2820 IT=1,MT
 2820 WRITE(IP,838)TIME(IT),(R1J(JF,IT),JF=1,4)
 2840 IF(NPRINT.EQ.1.OR.NPRINT.GT.5)GO TO 2999
      DO 2870 IZ=ISTART,ISTOP,2
      IF(ISTOP.LE.ISTART)GO TO 2850
      IZP1=IZ+1
      WRITE(IP,837)NUCNAM(K),K,IZ,IZP1
      WRITE(IP,838)(TIME(IT),(R2TOT(JF,IT,IZ),JF=1,4),TIME(IT),
     1(R2TOT(JF,IT,IZP1),JF=1,4),IT=1,MT)
      GO TO 2870
 2850 WRITE(IP,862)NUCNAM(K),K,IZ
      DO 2860 IT=1,MT
 2860 WRITE(IP,838)TIME(IT),(R2TOT(JF,IT,IZ),JF=1,4)
 2870 CONTINUE
 2999 CONTINUE
C******************************************* OUTPUT DOSE RATE RESULTS **
C**************************** FOR LOCAL DOSE STMTS 3000 TO 3100 ****
C*********************** FOR NONSPECIFIC DOSE STMTS 4000 TO 4100 ***
C********************* FOR TOTAL ALL NUCLIDES STMTS 5000 TO 5400 ***
      IF(NPRINT.LT.4)GO TO 9999
 3000 ISECT=3
      WRITE(IP,836)TITLE,ISECT,(HEAD(I,ISECT),I=1,4)
      DO 3100 IZ=ISTART,ISTOP
      DO 3100 K=1,NK
      WRITE(IP,840)IZ,NUCNAM(K),K
      INDEX=10*(K-1)+12
      READ(1'INDEX)((MANIL(ITE,IH),ITE=1,MT),IH=IORGS,IORGE)
      WRITE(IP,816)(ORGNAM(N),N=IORGS,IORGE)
      DO 3100 IT=1,MT
 3100 WRITE(IP,817)TIME(IT),(MANIL(IT,IH),IH=IORGS,IORGE)
 4000 ISECT=4
      WRITE(IP,836)TITLE,ISECT,(HEAD(I,ISECT),I=1,4)
      DO 4100 K=1,NK
      WRITE(IP,841)NUCNAM(K),K
      INDEX=10*(K-1)+10
      READ(1'INDEX)((MANIN(IT,IH),IT=1,MT),IH=IORGS,IORGE)
      WRITE(IP,816)(ORGNAM(N),N=IORGS,IORGE)
      DO 4100 IT=1,MT
 4100 WRITE(IP,817)TIME(IT),(MANIN(IT,IH),IH=IORGS,IORGE)
 5000 ISECT=5
      WRITE(IP,836)TITLE,ISECT,(HEAD(I,ISECT),I=1,4)
      DO 5200 IH=IORGS,IORGE
      DO 5200 IZ=ISTART,ISTOP,2
      IF(ISTOP.LE.ISTART) GO TO 5110
      IZP1=IZ+1
```

APPENDIX H   Main Program continued

```
FORTRAN IV G LEVEL  21                MAIN              DATE = 78096           22/36/04

 0423                WRITE(IP,900)ORGNAM(IH),IZ,IZP1
 0424                DO 5100 IT=1,MT
 0425                WRITE(IP,901)TIME(IT),(MAN2LF(IT,IH,IZ,JF),JF=1,4),
                    1MAN2L(IT,IH,IZ),
                    2TIME(IT),(MAN2LF(IT,IH,IZP1,JF),JF=1,4),MAN2L(IT,IH,IZP1)
 0426           5100 CONTINUE
 0427                GO TO 5200
 0428           5110 WRITE(IP,902) ORGNAM(IH),IZ
 0429                DO 5120 IT=1,MT
 0430                WRITE(IP,901)TIME(IT),(MAN2LF(IT,IH,IZ,J[illegible]=1,4),
                    1MAN2L(IT,IH,IZ)
 0431           5120 CONTINUE
 0432           5200 CONTINUE
 0433                DO 5400 IH=IORGS,IORGE
 0434                WRITE(IP,950)ORGNAM(IH)
 0435                DO 5300 IT=1,MT
 0436                WRITE(IP,951)TIME(IT),(MAN2NF(IT,IH,JF),JF=1,4),MAN2N(IT,IH)
 0437           5300 CONTINUE
 0438           5400 CONTINUE
               C*********** TO STMT 6500 OUTPUT DOSE SUMMARY TABLES **************
 0439           6000 ISECT=6
 0440                IF(IZONM.EQ.0)GO TO 9999
 0441                WRITE(IP,836)TITLE,ISECT,(HEAD(I,ISECT),I=1,4)
               C********************************** SET ZONE FOR TABLE ************
 0442                DO 6500 IZP1=1,IZONM
 0443                IZ=IZONE(IZP1)
               C*********************** IZ=10 MEANS NONSPECIFIC DOSE RATES ******
               C************************************** SET TIME FOR TABLE ********
 0444                DO 6500 ITR=ITSUMY,MT,ITSUMJ
 0445                IF(IZ.NE.10)WRITE(IP,853)IZ
 0446                IF(IZ.EQ.10)WRITE(IP,854)
 0447                WRITE(IP,855)TIME(ITR),(ORGNAM(N),N=IORGS,IORGE)
               C**************************** INITIALIZE SUBTOTAL SETTING *******
 0448                M1=1
 0449                M10=KSUB
               C***************************** ZERO REMOV=SUBTOTAL **************
 0450           6100 DO 6200 I=IORGS,IORGE
 0451           6200 REMOV(1,I)=0.0
 0452                DO 6300 K=M1,M10
 0453                INDEX=10*(K-1)+IZ
 0454                READ(1'INDEX)((MAN1L(ITE,IH),ITE=1,MT),IH=IORGS,IORGE)
               C************************************ WRITE TABLE ***************
 0455                WRITE(IP,856)K,NUCNAM(K),(MAN1L(ITR,IH),IH=IORGS,IORGE)
 0456                DO 6300 I=IORGS,IORGE
 0457           6300 REMOV(1,I)=REMOV(1,I)+MAN1L(ITR,I)
               C********************************** WRITE SUBTOTAL **************
 0458                WRITE(IP,857) (REMOV(1,I),I=IORGS,IORGE)
 0459                IF(M10.EQ.NK)GO TO 6400
 0460                M1=KSUB+1
 0461                M10=NK
 0462                GO TO 6100
               C********** WRITE TOTAL IF IZ= 10 MAN2N OR ELSE MAN2L **********
 0463           6400 IF(IZ.NE.10)WRITE(IP,858)(MAN2L(ITR,I,IZ),I=IORGS,IORGE)
```

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FORTRAN IV G LEVEL  21                MAIN              DATE = 78096            22/35/04

 0464          6800 IF(IZ.EQ.10)WRITE(IP,888)(MANZN(ITR,I),I=IORGS,IORGE)
 0465               GO TO 9999
 0466          9995 WRITE(IE,861)
 0467               GO TO 9999
 0468          9996 WRITE(IE,842)ISTART,MZ
 0469               GO TO 9999
 0470          9997 WRITE(IE,860)IORGS,NIMT
 0471               GO TO 9999
 0472          9998 WRITE(IE,846)ICHCK,CHECK
 0473          9999 CONTINUE
 0474           801 FORMAT(16I5)
 0475           802 FORMAT('1CASE NUMBER ',I3)
 0476           803 FORMAT(10A8)
 0477           805 FORMAT('1** DEFINITION OF ENVIRONMENTAL INPUTS',T60,'** DEFINITION
               1 OF PROBABILITY INPUTS'//8X,'JF    DEFINITION',T63,'IFLAG   DEFINI
               2TION'/8X,'--     ----------',T63,'-----   ----------'/9X,'1     AIR'
               3,T65,'0     PROBABILITY (PROB) CONSTANT'/9X,'2     GROUND SURFACE',
               4T65,'1     STEP FUNCTION AT TIME TP CHANGES PROB BY AMOUNT CP',
               5/,9X,'3    SURFACE WATER',T65,
               1'2     RAMP FUNCTION AT TP CHANGES PROB BY SLOPE CP'/9X,
               2'4    GROUND WATER',T65,'3     EXPONENTIAL FUNCTION AT TP CHANGES
               3PROB BY TIME CONSTANT CP'/,T65,'4      DELTA FUNCTION,',
               4' AT TIME TP RELEASE TO ENVIRONMENT IS AA1'///,
               5' ** PROBABILITY AND RELATED DATA'/3X,'JF          NJF    J        ',
               1  'NJJ       AA1',10X,'PROB',11X,'IFLAG',11X,'TP',16X,'CP'/3X,'--'
               2,6X,'---      -',7X,'---',7X,'---',10X,'----',11X,'-----',11X,'--',
               316X,'--'/)
 0478           806 FORMAT(8E10.2)
 0479           807 FORMAT(20A4)
 0480           808 FORMAT(A8,2X,7E10.2)
 0481           809 FORMAT(10X,7E10.2)
 0482           810 FORMAT(E10.2,I10,2E10.2)
 0483           811 FORMAT(3X,I2,5X,I3,4X,I2,5X,I3,2(5X,1PE9.2),9X,I3,2(8X,1PE12.5))
 0484           812 FORMAT(46X,1PE9.2,9X,I3,2(8X,1PE12.5))
 0485           813 FORMAT('1** SELECTED RESIDUAL ELEMENTS IN WASTE'/T8,'GRAMS AT STAR
               1T OF TERMINAL STORAGE'/' FOR TOTAL FUEL = ',F10.0,'METRIC TONS'/)
 0486           814 FORMAT(5X,A4,5X,1PE10.2)
 0487           815 FORMAT('1** SELECTED RADIONUCLIDES IN WASTE'/15X,'GRAMS IN WASTE
               1 VERSUS TIME IN YEARS')
 0488           816 FORMAT(/6X,'TIME',3X,10(A8,2X)/)
 0489           817 FORMAT(F11.0,1P10E10.2)
 0490           818 FORMAT(/' SPECIFIC ACTIVITY'/7X,'CI/G',1P10E10.2/'1')
 0491           819 FORMAT('1RADIONUCLIDE',8X,'DC1 DATA',7X,'DRC DATA',7X,'RKD DATA'/)
 0492           820 FORMAT(3X,A8,8X,3(1PE10.2,5X))
 0493           821 FORMAT('1** EDC(K,JF,IZ) DATA, (JF=1,2,3,4)',
               1', DEFAULT VALUES USED, EXCEPTING',A8,'READ IN',/)
 0494           822 FORMAT(//'    IZ=',I2,45X,'IZ=',I2/2X,2(1P4E10.2,4X))
 0495           823 FORMAT(2X,A8,2(1P4E12.2,4X))
 0496           824 FORMAT(///'1** DISPN(JF,IZ) DATA, (JF=1,2,3,4)'/)
 0497           825 FORMAT(///' ** ADJ1(JF,JFA,IZ),ADJ2(JF,JFA,IZ) DATA, (JFA=1,2,3,4)
               1'/)
 0498           826 FORMAT(2X,'IZ=',I2)
 0499           827 FORMAT(3X,'JF=',I2,7X,4(1PE10.2,2X,1PE10.2,4X))
```

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FORTRAN IV G LEVEL  21                MAIN              DATE = 78096           22/35/04

 0500            828 FORMAT('1** VOLINT(JF,MODE,NSP) DATA'/)
 0501            829 FORMAT('  IZ=',I2/5X,'JF      MODE      NSP=1 THRU',10X,'VOLINT')
 0502            830 FORMAT(5X,I2,6X,I2,12X,I2,6(3X,1PE10.2))
 0503            831 FORMAT('1** BIOFAC(K,JF,NSP) DATA'/)
 0504            832 FORMAT(' RADIONUCLIDE=',A8/5X,'JF      NSP=1 THRU',10X,'BIOFAC')
 0505            833 FORMAT('1** DOSFAC(K,JF,MODE,IH) DATA'/)
 0506            834 FORMAT(/' ORGAN = ',A8/T26,'JF=1',T51,'JF=2',T77,'JF=3',
                    1T103,'JF=4'/16X,4('MODE=1',7X,'MODE=2',7X))
 0507            835 FORMAT(3X,A8,8(3X,1PE10.2))
               C*** TO HAVE N LINES IN TITLE MUST CHANGE 3(T27,10A8/) IN 1 BELOW ***
               C*********** TO N(T27,10A8/) AND REMOVE CORRESPONDING # OF / ********
 0508            836 FORMAT(/,'1'/9(1X,132('#')/),10(/),T37,'AMRAW: ASSESSMENT METHOD',
                    1' FOR RADIOACTIVE WASTE MANAGEMENT',4(/),3(T27,10A8/),///,T51,
                    2'SECTION',I3/,5(/),T51,4A8,15(/),9(1X,132('#')/))
 0509            837 FORMAT('1RADIONUCLIDE: ',A8,' (K=',I2,')'/1X,29('-')/' CONCENTRATI
                    1ONS AT ENVIRONMENT INPUT RECEPTOR, R2TOT      UNITS: JF=1 MICROCURI
                    2E*YEARS/CUBIC CM'/' JF=2 MICROCURIES/SQUARE CM, JF=3 AND 4 MICROCU
                    3RIES/CUBIC CM'//' ZONE=',I2,T71,'ZONE=',I2,//
                    42(14X,'JF=1        JF=2        JF=3        JF=4',18X)/
                    52(5X,'TIME       AIR       GROUND     SURFACE    GROUND',17X)/
                    62(23X,'SURFACE    WATER      WATER',18X))
 0510            838 FORMAT(0PF10.0,1P4E10.2,18X,0PF8.0,1P4E10.2)
 0511            839 FORMAT('1RADIONUCLIDE: ',A8,' (K=',I2,')'/1X,29('-')/' RELEASE INC
                    1REMENTS TO PRELIMINARY ENVIRONMENT INPUT'/' RECEPTORS, RIJ, FROM A
                    2LL RELEASE EVENTS, IN CURIES'//14X,'JF=1         JF=2         JF=3
                    3JF=4'/5X,'TIME       AIR       GROUND     SURFACE    GROUND'/23X,'SURFA
                    4CE    WATER      WATER')
 0512            840 FORMAT('1** AVERAGE ANNUAL LOCAL DOSE TO INDIVIDUAL, MANIL, IN MIL
                    1LIREMS/YEAR'//' ZONE=',I2,'... NUCLIDE=',A8,'  K=',I3/)
 0513            841 FORMAT('1** AVERAGE ANNUAL NONSPECIFIC DOSE TO POPULATION, MANIN,
                    2IN MANREMS/YEAR'//' NONSPECIFIC ... NUCLIDE=',A8,'  K=',I3/)
 0514            842 FORMAT(1X,132('*')/' ERROR:  VALUE OF ZONE',I5/'  OUTSIDE OF RANGE
                    1 OF MAXIMUM ZONE (',I2,')'/1X,132('*')//)
 0515            843 FORMAT(5X,I2,12X,I2,6(3X,1PE10.2))
 0516            844 FORMAT('1')
 0517            845 FORMAT(19A4,I2)
 0518            846 FORMAT(9(1X,132('*')/)//T54,'ERROR NEAR CHECK POINT ',
                    *I2//1X,19A4//9(1X,132('*')/))
 0519            847 FORMAT('1RADIONUCLIDE: ',A8,' (K = ',I2,')'/1X,31('-')//' RELEASE
                    *FRACTIONS BY EACH CUTSET, RELOUT'//' TIME',T14,'JF',T20,
                    *'INITIAL RELEASE FRACTIONS')
 0520            848 FORMAT(1X,19A4,I2)
 0521            849 FORMAT(/////' ** ZONALO(JF,IZ) DATA, (JF=1,2,3,4)'/)
 0522            850 FORMAT(/////' ** ZONDEP(IZ) DATA'////,4X,9(A3,I2,5X))
 0523            851 FORMAT('1** AREAW(IZ) DATA'////,4X,9(A3,I2,5X))
 0524            860 FORMAT(2X,9(1PE10.2))
 0525            852 FORMAT('1TIME',T14,'JF',T20,33HINITIAL RELEASE FRACTIONS, CONT'D)
 0526            853 FORMAT('1',T15,'  AVERAGE ANNUAL LOCAL DOSE TO INDIVIDU',
                    1'AL, MANIL, IN ZONE',I2,', IN MILLIREMS/YEAR',//)
 0527            854 FORMAT('1',T15,'  AVERAGE ANNUAL NONSPECIFIC DOSE TO PO',
                    1'PULATION, MANIN, IN MANREMS/YEAR',//)
 0528            855 FORMAT(T38,0PF9.0,' YEARS#',/,1X,94('-'),/,'    K  NUCLIDE',1X,
                    18(2X,A8),/,1X,94('-'))
```

APPENDIX H   Main Program concluded

```
FORTRAN IV G LEVEL  21                   MAIN               DATE = 78096          22/35/04
 0529           856 FORMAT(2X,I2,2X,A8,8(1PE10.2))
 0530           857 FORMAT(1X,94('-'),/,5X,'SUB TOTAL',8(1PE10.2),/,1X,94('-'))
 0531           858 FORMAT(7X,'TOTAL',2X,8(1PE10.2),/,1X,94('-'),
                   1/,'  #TIME SINCE START OF REPOSITORY OPERATIONS.')
 0532           859 FORMAT(/////,' ** GROUND WATER PARAMETERS',///,3X,
                   1'GROUND WATER SEEPAGE VELOCITY, VX, IN METERS/DAY =',1PE10.2,/,
                   23X,'POROSITY OF SOLID MEDIUM, PORE =',1PE10.2,/,3X,
                   3'BULK SOLID DENSITY, BULKD, IN GRAMS/CUBIC CM =',1PE10.2,/,3X,
                   4'DISPERSIVITY COEFFICIENTS, IN METERS: AXIAL, AL =',1PE10.2,
                   *2X,'TRANSVERSE, AT =',1PE10.2,//,3X,
                   5'AQUIFER VALUES, IN METERS: HEIGHT, HT=',1PE10.2,
                   */,3X,'DISTANCE FROM SOURCE TO EMERGENCE, XL(IZ)',
                   *' EFFECTIVE WIDTH, YW(IZ)',/,3X,
                   *'CONCENTRATION AT YY = AVERAGE CONCENTRATION IN YW',//,
                   *4X,'ZONE',8X,9(A3,I2,5X))
 0533           870 FORMAT(3X,'XL(IZ)',2X,9(1PE10.2))
 0534           871 FORMAT(3X,'YW(IZ)',2X,9(1PE10.2))
 0535           872 FORMAT(3X,'YY(IZ)',2X,9(1PE10.2))
 0536           873 FORMAT(/,3X,
                   6'EXPOSED AREA OF SOLIDIFIED WASTE SPECIMEN, FS, IN SQUARE CM =',
                   *1PE10.2,/,3X,
                   7'VOLUME OF SOLIDIFIED WASTE SPECIMEN, VS, IN CUBIC CM =',1PE10.2,/
                   8,3X,'TOTAL CANISTER INVENTORY, CINV =',1PE10.2,/,3X,
                   9'ASSUMED NUMBER OF CANISTER FAILURES, CFAI =',1PE10.2)
 0537           860 FORMAT(1X,132('*')/' ERROR:  INVALID ORGAN NUMBER =',I5,5X,
                   1'MAXIMUM NUMBER OF ORGANS =',I2,/,1X,132('*'))
 0538           861 FORMAT(1X,132('*')/' ERROR:  ATTEMPTED REPOSITORY OPERATION ',
                   1'WITHOUT SUBSEQUENT ENVIRONMENT TIME INCREMENT',/,1X,132('*'))
 0539           862 FORMAT('1RADIONUCLIDE: ',A8,' (K=',I2,')'/1X,29('-')/' CONCENTRATI
                   1ONS AT ENVIRONMENT INPUT RECEPTOR, RETOT     UNITS: JF=1 MICROCURI
                   2E*YEARS/CUBIC CM'/' JF=2 MICROCURIES/SQUARE CM, JF=3 AND 4 MICROCU
                   3RIES/CUBIC CM'//' ZONE=',I2,//
                   41(14X,'JF=1        JF=2        JF=3        JF=4',18X)/
                   51(5X,'TIME      AIR       GROUND     SURFACE    GROUND',17X)/
                   61(23X,'SURFACE    WATER      WATER',18X))
 0540           900 FORMAT('1** AVERAGE ANNUAL LOCAL DOSE TO INDIVIDUAL, MAN2LF FOR JF
                   1=1 TO 4, MAN2L FOR TOTAL, IN MILLIREMS/YEAR',//,4X,
                   2'TOTAL FOR ALL NUCLIDES',T63,A8,//,
                   3'  ZONE=',I2,T71,'ZONE=',I2,//,2(13X,'JF=1        JF=2        JF=3
                   4  JF=4',13X),/,2(4X,'TIME      AIR       GROUND     SURFACE    GROUND
                   5   TOTAL',3X),/,2(22X,'SURFACE    WATER      WATER',13X))
 0541           901 FORMAT(F9.0,1P5E10.2,1X,0P1F9.0,1P5E10.2)
 0542           902 FORMAT('1** AVERAGE ANNUAL LOCAL DOSE TO INDIVIDUAL, MAN2LF FOR JF
                   1=1 TO 4, MAN2L FOR TOTAL, IN MILLIREMS/YEAR',//,4X,
                   2'TOTAL FOR ALL NUCLIDES',T63,A8,//,
                   3'  ZONE=',I2,//,1(13X,'JF=1        JF=2        JF=3        JF=4',
                   4  13X),/,1(4X,'TIME      AIR       GROUND     SURFACE    GROUND    ',
                   5  'TOTAL',3X),/,1(22X,'SURFACE    WATER      WATER',13X))
 0543           950 FORMAT('1** AVERAGE ANNUAL NONSPECIFIC DOSE TO POPULATION, MAN2NF
                   1FOR JF=1 TO 4, MAN2N FOR TOTAL, IN MANREMS/YEAR',//,4X,
                   2'TOTAL FOR ALL NUCLIDES',T63,A8,//,16X,'JF=1        JF=2        JF=3',
                   3'        JF=4'/,7X,'TIME      AIR       GROUND     SURFACE    GROUND',
                   4'    TOTAL',/,23X,'SURFACE    WATER      WATER')
 0544           951 FORMAT(F12.0,1P5E10.2)
 0545               STOP
 0546               END
```

APPENDIX H   Subprograms

```
FORTRAN IV G LEVEL  21                  FAULT              DATE = 78096          22/35/04

 0001               SUBROUTINE FAULT(TIME,PROB,A1,JF,J,NJJJ,ITR,K,CONCI)
 0002               IMPLICIT INTEGER*2 (I-N)
 0003               COMMON/BFAULT/ PROBB,AA1,TP,CP,IFLAG
 0004               COMMON/FDLEA/ CPA1,XR,DELTIM,I1
 0005               COMMON/FCRATO/DELTL
 0006               DIMENSION PROBB(4,9,4),AA1(4,9),TIME(50),TP(4,9,4),CP(4,9,4)
 0007               INTEGER*2 IFLAG(4,9,4)
 0008               PROB=1.
              C************************* NJJJ=# OF PROB ASSOCIATED WITH EACH CUTSET. **
 0009               DO 100 I=1,NJJJ
 0010               CPROB=PROBB(JF,J,I)
 0011               IF(TIME(ITR).LT.TP(JF,J,I))GO TO 50
 0012               DELTIM=TIME(ITR)-TP(JF,J,I)
 0013               I1=IFLAG(JF,J,I)+1
 0014               GO TO(50,40,30,20),I1
              C*************************************** PROB IS DELTA FUNCTION **
 0015               IF(DELTIM.EQ.0.)GO TO 10
 0016               GO TO 50
 0017            10 CPROB=1./DELTL
 0018               GO TO 50
              C******************************************* PROB CHANGES EXPONENTIALLY **
 0019            20 CPROB=CPROB*EXP(CP(JF,J,I)*DELTIM)
 0020               GO TO 50
              C*************************************** PROB CHANGES BY RAMP FUNCTION. **
 0021            30 CPROB=CPROB + CP(JF,J,I)*DELTIN
 0022               GO TO 50
              C*************************************** PROB CHANGES BY STEP FUNCTION. **
 0023            40 CPROB=CPROB+CP(JF,J,I)
              C********************************************* PROB IS CONSTANT *******
 0024            50 PROB=PROB*CPROB
 0025           100 CONTINUE
 0026               A1=AA1(JF,J)
 0027               IF(PROB.EQ.0.0)GO TO 155
 0028               IF(JF.EQ.4)GO TO 156
 0029               RETURN
 0030           155 CONCI=0.0
 0031               RETURN
 0032           156 A1=RLEACH(K,ITR,CONCI,X2)*CPA1*X2*365.
 0033               IF(XR.EQ.0.0)A1=0.0
 0034               IF(XR.EQ.0.0)RETURN
 0035               A1=A1/XR
 0036               RETURN
 0037               END
```

APPENDIX B   Sub-programs

```
FORTRAN IV G LEVEL  21                    RLEACH               DATE = 78096              22/35/04

                FUNCTION RLEACH(K,ITR,CONC1,A2)
                IMPLICIT INTEGER*2 (I-N)
                COMMON/BLEACH/ DC1(25),DRC(25),X(25,50),PS,VS,SPACT(25),CINV
                COMMON/FOLEA/ CFAI,NN,DELTIN,I1
                COMMON/FCRATO/DELTL
                JN=5
                DTIME=DELTL
                IF(I1.EQ.2) DTIME=DELTIN
                IF(DTIME.GE.100.) JN=10
                AJN=JN
                DELTLD=DTIME*365./AJN
                CONC1=0.
                CONC2=0.
                STEM=SQRT(DC1(K)/3.1416)
                CC1=(2.*PS*X(K,ITR)*CFAI)/(VS*CINV)
                TERM=STEM*SQRT(DELTLD)
                DO 85 I=1,JN
                IF(DTIME.GE.10.)GO TO 65
                CC2=1.+.5*DRC(K)*DELTLD
                CONC2=CONC2+CC1*CC2*TERM
                CONC1=CONC1+CC1*CC2*TERM*SPACT(K)
                GO TO 75
             65 CC3=CC1/2.
                CC4=SQRT(DC1(K)*DRC(K))
                CC5=DELTLD+.5/DRC(K)
                CONC2=CONC2+CC3*CC4*CC5
                CONC1=CONC1+CC3*CC4*CC5*SPACT(K)
            75  RLEACH=CONC2
                IF(RLEACH .GT. 3.2E+07)RLEACH=3.2E+07
            85  CONTINUE
                RLEACH=RLEACH/(CFAI*PS*DTIME*365.)
                A2=PS*DELTL
                RETURN
                END
```

APPENDIX H   Sub-programs continued

```
FORTRAN IV G LEVEL  21                 TRINP              DATE = 78096           22/35/04

                SUBROUTINE TRINP(DELT2,DELT3,DELT4,XR,XE,XEM1,XEM2,TRL,
               1DECFAC,A2,XL,XE3,QFAC,ITE,ITRE,IW,JF,RKD,RKDMAX,K)
                IMPLICIT INTEGER*2 (I-N)
                DIMENSION RKD(25)
                COMMON/DTRINP/ Y2,Y3,I2,IFDIVW
                COMMON/CTRINP/ CRMIN,DFMIN
                DECFAC=1.
                GO TO(1,1,1,30),JF
              1 IF(DELT4.EQ.0.)GO TO 5
                Y=1.
                GO TO 62
              5 A2=1.
                GO TO 70
             30 IF(XL.LT.1.0) GO TO 68
                IF(RKD(K).GT.RKDMAX) GO TO 68
                DELTIM=DELT2*365.
                DELTA=DELT3-DELT2
                IIN=2
                IF(IFDIVW.EQ.0)GO TO 50
                IF(DELTA.GE.5000..AND.RKD(K).LT.1.)IIN=11
                IF(DELTA.GE.50000.)IIN=6
                IF(DELTA.GE.50000..AND.RKD(K).LT.1.)IIN=101
             50 RIN=IIN
                DELINC=DELTA*365./(RIN-1.)
                XINC=(XE-XEM1)/(RIN-1.)
                A2=0.0
                DO 400 I=1,IIN
                Y=CRATIO(DELTIM,XL,DELTA,DELINC,I2)
                IF(Y.LE.1.) GO TO 100
                Y=1.
          100   IF(XR.LE.1.0E-40)GO TO 300
                IF(IW.EQ.3) GO TO 200
                DECFAC=XEM1/XR
                GO TO 250
            200 IF(ITE.LE.ITRE) DECFAC=1.0
                IF(ITE.GT.ITRE) DECFAC=XEM1/XE3
            250 IF(Y.LT.CRMIN.OR.DECFAC.EQ.0.) GO TO 300
                IF(DECFAC.LT.DFMIN) DECFAC=DFMIN
                A2=A2+Y*DECFAC
            300 DELTIM=DELTIM+DELINC
                XEM1=XEM1+XINC
            400 CONTINUE
                A2=A2/RIN
                GO TO 70
             62 IF((XEM1+XEM2).LE.10.E-40.OR.ABS(TRL*DELT4).GE.80.)GO TO 68
                IF(IW.EQ.3.AND.ITE.LE.ITRE)GO TO  64
                DECFAC=(XE+XEM1)/(XEM1+XEM2)
                GO TO  66
             64 DECFAC=1.0-((DELT3-DELT2)*QFAC)
             66 TRR1=TRL*DELT4
                IF(TRR1.GT.150.) GO TO 68
                A2=DECFAC*Y*EXP(-TRR1)
                GO TO 70
             68 A2=0.
             70 RETURN
                END
```

APPENDIX H   Sub-programs continued

```
FORTRAN IV G LEVEL  21                CRATIO            DATE = 78096            22/35/04

              FUNCTION CRATIO(DELTIM,XL,DELTA,DELINC,IZ)
              IMPLICIT INTEGER*2 (I-N)
              DIMENSION RKD(25),TIME(50),YY(8),YW(8)
              COMMON/BCRATO/ RKD,CONCI,TIME,VX,PORE,AL,AT,HT,BULKD,YW,ITR,NT,
             1ITE,K,GNDDIS,YY
              COMMON/FCRATO/DELTL
              IF(CONCI.EQ.0..OR.CONCI.LE.1.E-60)CRATIO=0.
              IF(CONCI.EQ.0..OR.CONCI.LE.1.E-60)RETURN
              VPORE=VX
              DXX=AL*VPORE
              DYY=AT*VPORE
              IF(CONCI.LE.1.E-70)CONCI=0.
              SSAM=CONCI/HT
              DR1=BULKD*RKD(K)/PORE
              RD=1. + DR1
              EX=DXX/RD
              EY=DYY/RD
              EE=(EX*EY)**0.5
              U=VPORE/RD
              IF(DELTIM.LE.0.)CRATIO=0.
              IF(DELTIM.LE.0.)RETURN
            6 TEE=EE*DELTIM
              TEX=4.*3.14159*TEE
              IF(SSAM.GT.1.E+30.OR.TEX.LT.1.E-45)TER=1./(HT*TEX)
              IF(SSAM.GT.1.E+30.OR.TEX.LT.1.E-45)GO TO 31
              TER=SSAM/TEX
         31   TT1=ABS(XL-U*DELTIM)**2/(4.*EX*DELTIM)
              TT3=(YY(IZ)**2)/(4.*EY*DELTIM)
              TT4=ABS(TT1+TT3)
              IF(TT4.GE.90.)GO TO 10
              TT4=EXP(-TT4)
              GO TO 34
           10 TT4=0.
         34   IF(SSAM.GT.1.E+30.OR.TEX.LT.1.E-45)GO TO 33
              TER=TER/CONCI
           33 CONC=TER*TT4
              GNDDIS=YW(IZ)*HT*VPORE*PORE*DELTA*365.
              GNDINC=YW(IZ)*HT*VPORE*PORE*DELINC
              CONC=CONC*GNDINC
              CRATIO=CONC
              IF(CRATIO.GT.1.)CRATIO=1.
              RETURN
              END
```

APPENDIX H   Sub-programs concluded

```
FORTRAN IV G LEVEL  21              TRMAN              DATE = 78096          22/35/04

      SUBROUTINE TRMAN(K,ITE,IZ,NSS,C)
      IMPLICIT INTEGER*2 (I-N)
      DIMENSION BIOFAC(25,4,6),VOLINT(4,2,6,8),DOSFAC(25,4,2,8)
      COMMON/BTRMAN/ BIOFAC,VOLINT,DOSFAC,NSP,IFLAGE,JF,IH,DELTE
      INTEGER*2 NSP(6),IFLAGE(4,2,6)
      NS=NSP(JF)
      C=0.
      DO 20 MODE=1,2
      CSUM=0.
      IF(DOSFAC(K,JF,MODE,IH).EQ.0.)GO TO 20
C********************************* SUM ALL SUBPATHWAYS TO DOSE TO MAN. **
      DO 10 I=1,NS
      IF(IFLAGE(JF,MODE,I).NE.NSS)GO TO 10
      FACT=BIOFAC(K,JF,I)
      IF(MODE.EQ.1)FACT=1.
      GO TO(4,2,6,6),JF
    2 IF(MODE.EQ.1)GO TO 6
    4 CSUM=CSUM+FACT*VOLINT(JF,MODE,I,IZ)/DELTE
      GO TO 10
    6 CSUM=CSUM+FACT*VOLINT(JF,MODE,I,IZ)
   10 CONTINUE
C********************* DETERMINE TRANSFER COEFFICIENT FOR DOSE TO MAN. **
      C=C+CSUM*DOSFAC(K,JF,MODE,IH)
   20 CONTINUE
      RETURN
      END
```

APPENDIX I

FLOWCHART

Figure I-1 shows a simplified flowchart for AMRAW-A. The chart represents flow through the code for a specified waste management phase, such as repository operations or terminal storage. The reader is referred to Vol. I, Generic Description of AMRAW-A, for detailed description of each step through the model.

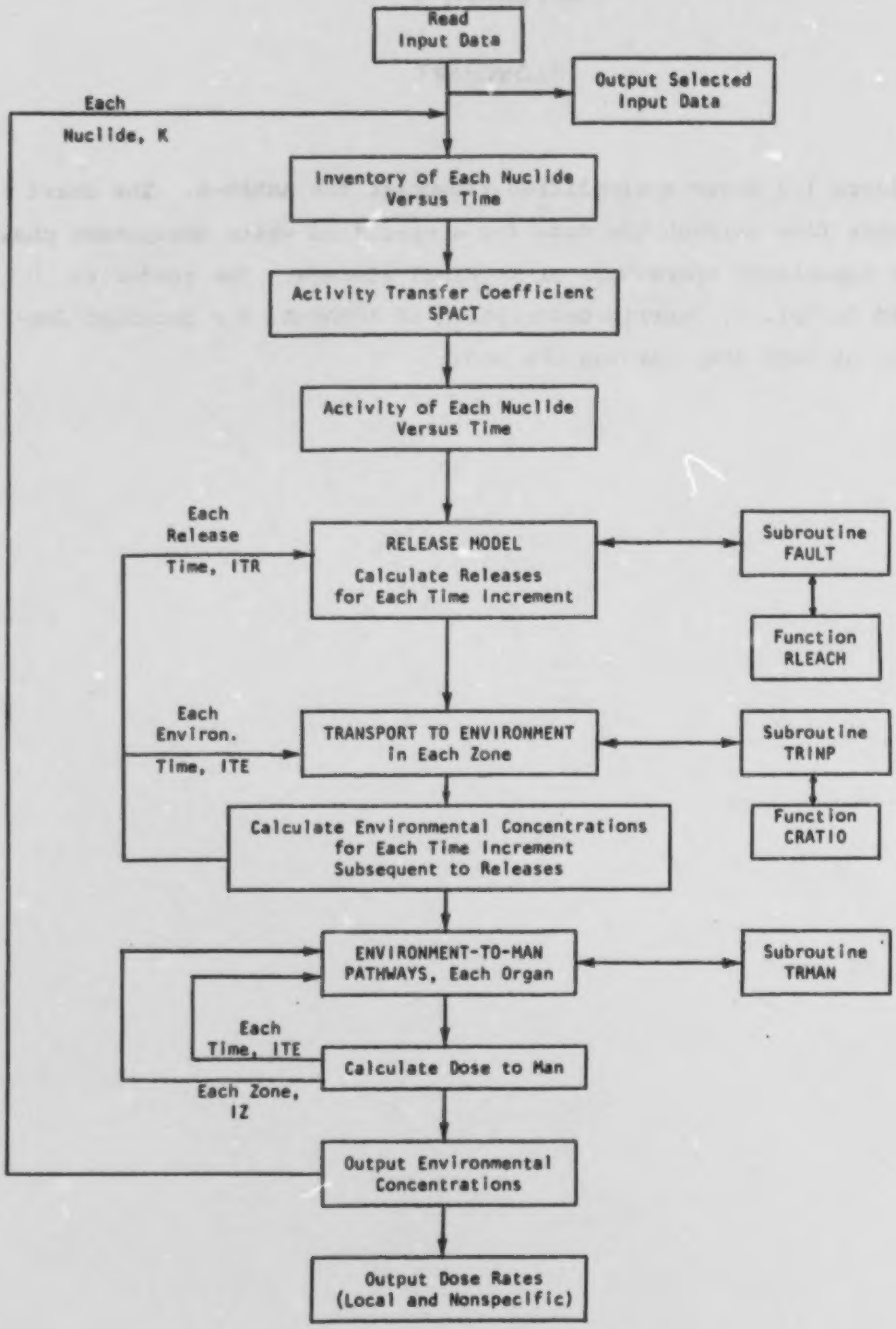
Read Input Data
Output Selected Input Data
Each Nuclide, K
Inventory of Each Nuclide Versus Time
Activity Transfer Coefficient SPACT
Activity of Each Nuclide Versus Time
Each Release Time, ITR
RELEASE MODEL
Calculate Releases for Each Time Increment
Subroutine FAULT
Function RLEACH
Each Environ. Time, ITE
TRANSPORT TO ENVIRONMENT in Each Zone
Subroutine TRINP
Function CRATIO
Calculate Environmental Concentrations for Each Time Increment Subsequent to Releases
ENVIRONMENT-TO-MAN PATHWAYS, Each Organ
Subroutine TRMAN
Each Time, ITE
Calculate Dose to Man
Each Zone, IZ
Output Environmental Concentrations
Output Dose Rates (Local and Nonspecific)

Figure I-1. AMRAW-A simplified flowchart.

APPENDIX J

AUXILIARY PROGRAMS

Auxiliary programs for use with AMRAW are described in this appendix.

1) COMPRESS - a program for preparing an AMRAW-B input file from AMRAW-A output.

2) POLYEPA - a program for preparing inventory data matrix by curve fitting source data to prescribed time specified in AMRAW input.

3) SENDY - a program for comparing results in tables from AMRAW run with corresponding tables from another run.

1. COMPRESS. All of the AMRAW-A output tables in Section 3 (Local Dose to Individual) and Section 4 (Nonspecific Dose to Population) comprise the major input to AMRAW-B (Economic Model). COMPRESS is an auxiliary program, written in PL-1 and Fortran IV language, which finds these tables in the full output stored on tape, strips off the headings and left hand column of time, and outputs a continuous "compressed" file in a form ready to be read by AMRAW-B. The program may be used separately to produce AMRAW-B input files from AMRAW-A output, or it may be joined to AMRAW-B to process data directly. Appendix T in Part 2 describes and presents a listing of COMPRESS, including JCL, as run on the IBM 360/67 computer at UNM.

2. POLYEPA. The repository inventory matrix input to AMRAW consists of quantities of each radionuclide at each time specified for calculation, over the total time range considered. However, source data are generally available listed for time which do not match the intended calculation times and also are usually not subdivided into sufficiently short time increments. POLYEPA is a program written in CALL-OS FORTRAN which uses a cubic spline curve-fitting technique for interpolation to adjust quantities to the required times and furnish the required intermediate values. POLYEPA reads in the name of NK isotopes K together with inventories X(I, K) at various time points I. For each isotope, there are a total of MT input time points for use in interpolating MTADJ output

data points. The output results can be written either on the terminal or stored in a data file "POLYDD" in the user's CALL-OS user library, for subsequent use as a portion of the AMRAW input data file. Before running POLYEPA, its input is assembled in a data file named "POLYDATA," stored in the user's CALL-OS user library.

Description of Card Input. One card of each type is required except as noted for card types 4 and 5.

Card Type	Format and Item	Description
1	Free format	
	MT	Number of input data time
	MS	Number of time intervals corresponding to the repository operations phase.
	MTADJ	Number of interpolated output time points.
	NK	Number of radioisotopes.
	MC	Number of columns in output tables.
2	Free format	
	TIME (I)	Time in years at each of MT input time points.
3	Free format	
	TIMEAD (I)	Time in years at each of MTADJ output time points.

NK sets of card types 4 and 5 are required:

Card Type	Format and Item	Description
4	FORMAT (A8)	
	NUCNAM (K)	Name of radioisotope (e.g., Sr-90, NB-93m, or PU-239).
5	Free format	
	X (I, K)	MT values of masses of isotope K at time points I.

Listing. Table J-1 is a listing of POLYEPA.

Table J-1.

```
      REAL*8 TIME(17),TIMLG(17),TIMEAD(55),XS(50),U,SEVAL,&
      X(17,25),XLG(17,25),B(17,25),C(17,25),D(17,25),NUCNAM(25)
      INTEGER MTSAV(26),MTA,MK,ISAV,MT,M1,M7,M10,MTADJ
      WRITE(6,500)
      CALL OPEN(1,'DATAPOLY','INPUT')
      CALL OPEN(9,'DDPOLY','OUTPUT')
      READ(1,*)MT,MS,MTADJ,MK,MC
      READ(1,*)(TIME(I),I=1,MT)
      READ(1,*)(TIMEAD(I),I=1,MTADJ)
      MSM1=MS-1
      MP=MTADJ+MSM1
          DO 10 I=MS,MT
          IMM=I-MSM1
10        TIMLG(IMM)=DLOG10(TIME(I))
      DO 50 K=1,MK
      READ(1,910)NUCNAM(K)
      READ(1,*)(X(I,K),I=1,MT)
          DO 20 I=MS,MT
          IMM=I-MSM1
          IF(X(I,K).GT.0.0D0)GO TO 20
          ISAV=I-1-MSM1
          GO TO 40
20        XLG(IMM,K)=DLOG10(X(I,K))
      ISAV=MT-MSM1
40    MTSAV(K)=ISAV
50    CONTINUE
          DO 60 K=1,MK
          MTA=MTSAV(K)
60        CALL SPLINE(MTA,MK,K,TIMLG,XLG,B,C,D)
 1    WRITE(6,501)
      READ(5,*)IANS
      IF(IANS.EQ.1)GO TO 3
      IF(IANS.GT.3)GO TO 1
      PAUSE 'ROLL PAPER TO BEGINNING OF CLEAN SHEET AND HIT RETURN'
 3    GO TO(2,2,4),IANS
 2    DO 90 I1=1,MK
      DO 61 I=1,MSM1
61    XS(I)=X(I,I1)
      MTA=MTSAV(I1)
      L=1
      M1=1
      M7=7
      DO 80 I=1,MTADJ,7
          DO 70 K=1,7
          IF(I+K-1.GT.MTADJ)GOTO70
          U=DLOG10(TIMEAD(I+K-1))
          XS(I+K+5)=SEVAL(MTA,MK,I1,U,TIMLG,XLG,B,C,D)
          XS(I+K+5)=10.0D0**XS(I+K+5)
70        CONTINUE
80    CONTINUE
      DO 81 I=1,MP,7
      IF(IANS.EQ.1)WRITE(9,930)NUCNAM(I1),L,(XS(K),K=M1,M7)
      IF(IANS.EQ.2)WRITE(6,930)NUCNAM(I1),L,(XS(K),K=M1,M7)
      L=L+1
      IF(M7.GE.MP)GO TO 90
```

Table J-1. (continued)

```
      M1=M7+1
      M7=M7+7
      IF(M7.GT.MP)M7=MP
   81 CONTINUE
   90 CONTINUE
      GO TO 1
    4 WRITE(6,900)
      M1=1
      M10=MC
   51 WRITE(6,925)(NUCNAM(K),K=M1,M10)
      DO 53 I=1,MT
   53 WRITE(6,940)TIME(I),(X(I,K),K=M1,M10)
      IF(M10.GE.MK)GO TO 55
      M1=M10+1
      M10=M10+MC
      IF(M10.GT.MK)M10=MK
      GO TO 51
   55 WRITE(6,920)
      M1=1
      M10=MC
   65 WRITE(6,925)(NUCNAM(K),K=M1,M10)
      DO 67 I=1,MSM1
   67 WRITE(6,940)TIME(I),(X(I,K),K=M1,M10)
      DO 82 I=1,MTADJ
      U=DLOG10(TIMEAD(I))
          DO 71 K=M1,M10
          MTA=MTSAV(K)
          XS(K)=SEVAL(MTA,MK,K,U,TIMLG,XLG,B,C,D)
   71     XS(K)=10.0D0**XS(K)
          IF(XS(K).LT.1.0E-25)XS(K)=0.00
   82 WRITE(6,940)TIMEAD(I),(XS(K),K=M1,M10)
      IF(M10.GE.MK)GO TO 999
      M1=M10+1
      M10=M10+MC
      IF(M10.GT.MK)M10=MK
      GO TO 65
      GO TO 1
  999 STOP
  500 FORMAT(' 1=WRITE TO DATA FILE'/%
     ' 2=WRITE DATA FILE FORMATTED OUTPUT ON TERMINAL'/%
     ' 3=WRITE FORMATTED FOR EPA REPORT')
  501 FORMAT(' ENTER REQUEST')
  900 FORMAT(///'  ** INPUT DATA'//4X,'PROPERTIES OF ACCUMULATED 10 YEAR%
OLD WASTE AS A FUNCTION OF AGE.'//T51,'CONCENTRATION, GRAMS'/)
  910 FORMAT(A8)
  920 FORMAT(///'  *** OUTPUT RESULTS'//T51,%
'CONCENTRATIONS, GRAMS')
  925 FORMAT('0TIME(YRS)',10(2X,A8))
  930 FORMAT(A8,I2,7(1PE10.2))
  940 FORMAT(F10.0,10(1PE10.2))
      END
      SUBROUTINE SPLINE(N,MK,K,X,Y,B,C,D)
      INTEGER N,MK,K
      REAL*8 X(17),Y(17,25),B(17,25),C(17,25),D(17,25),T
       INTEGER NM1,IB,I
```

Table J-1. (concluded)

```
      NM1 = N-1
      IF ( N .LT. 3 ) GO TO 50
      D(1,K) = X(2) - X(1)
      C(2,K) = (Y(2,K) - Y(1,K))/D(1,K)
      DO 10 I = 2, NM1
         D(I,K) = X(I+1) - X(I)
         B(I,K) = 2.*(D(I-1,K) + D(I,K))
         C(I+1,K) = (Y(I+1,K) - Y(I,K))/D(I,K)
         C(I,K) = C(I+1,K) - C(I,K)
   10 CONTINUE
      B(1,K) = -D(1,K)
      B(N,K) = -D(N-1,K)
      C(1,K) = 0.
      C(N,K) = 0.
      IF ( N .EQ. 3 ) GO TO 15
      C(1,K) = C(3,K)/(X(4)-X(2)) - C(2,K)/(X(3)-X(1))
      C(N,K) = C(N-1,K)/(X(N)-X(N-2)) - C(N-2,K)/(X(N-1)-X(N-3))
      C(1,K) = C(1,K)*D(1,K)**2/(X(4)-X(1))
      C(N,K) = -C(N,K)*D(N-1,K)**2/(X(N)-X(N-3))
   15 DO 20 I = 2, N
         T = D(I-1,K)/B(I-1,K)
         B(I,K) = B(I,K) - T*D(I-1,K)
         C(I,K) = C(I,K) - T*C(I-1,K)
   20 CONTINUE
      C(N,K) = C(N,K)/B(N,K)
      DO 30 IB = 1, NM1
         I = N-IB
         C(I,K) = (C(I,K) - D(I,K)*C(I+1,K))/B(I,K)
   30 CONTINUE
      B(N,K) = (Y(N,K) - Y(NM1,K))/D(NM1,K) + D(NM1,K)*(C(NM1,K) + 2.*C(N,K))
      DO 40 I = 1, NM1
         B(I,K) = (Y(I+1,K) - Y(I,K))/D(I,K) - D(I,K)*(C(I+1,K) + 2.*C(I,K))
         D(I,K) = (C(I+1,K) - C(I,K))/D(I,K)
         C(I,K) = 3.*C(I,K)
   40 CONTINUE
      C(N,K) = 3.*C(N,K)
      D(N,K) = D(N-1,K)
      RETURN
   50 IF ( N .LT. 2 ) RETURN
      B(1,K) = (Y(2,K)-Y(1,K))/(X(2)-X(1))
      C(1,K) = 0.
      D(1,K) = 0.
      RETURN
      END
      REAL FUNCTION SEVAL*8 (N,MK,KK,U,X,Y,B,C,D)
      INTEGER N,MK,KK
      REAL*8 U,X(17),Y(17,25),B(17,25).C(17,25),D(17,25),DX
      INTEGER I, J, K
      DATA I/1/
      IF ( I.GE.N ) I = 1
      IF ( U .LT. X(I) ) GO TO 10
      IF ( U .LE. X(I+1) ) GO TO 30
   10 I = 1
      J = N + 1
   20 K = (I+J)/2


   IF ( U .LT. X(K) ) J = K
   IF ( U .GE. X(K) ) I = K
   IF ( J .GT. I+1 ) GO TO 20
30 DX = U - X(I)
   SEVAL = Y(I,KK) + DX*(B(I,KK) + DX*(C(I,KK) + DX*D(I,KK)))
   RETURN
   END
```

3. SENDY. This is an auxiliary program developed to help compare results from different computer runs of AMRAW-A. It handles two cases at a time. AMRAW-A stores output results on magnetic tape; SENDY reads corresponding matrices of two different cases from the tape. It can compare results from two cases by finding the ratio of elements of the two matrices, or calculate the normalized values in each matrix (e.g., metric tons of initial waste stored). There are provisions in SENDY for users to modify the program to perform other mathematical manipulations on the two matrices.

SENDY indentifies the particular matrix by the unique headings of the matrix. It compares the matrix heading it reads on the tape with that of the input heading read from a card. Once the matrix heading on the tape matches that on the card, it reads and stores the entire matrix in the core. Input to SENDY consists of identification of magnetic tape volumes which store the two cases to be compared, headings identifying the matrix in each of the cases to be compared, and commands the comparison or normalizing operation to be performed.

AMRAW-A points out 9 variables in its output: 3 in section 2, one in sections 3 and 4, and 4 in section 5. In order to simplify the modification of SENDY to suit different users, the program is partitioned into 7 parts; namely, JCLSENDY, SENDYGEN, SENDY3A, SENDY4A, SENDY5A, SENDY5B and DDSENDY. A complete SENDY run consists of these 7 parts, plus input cards with commands and headings (see Figures J-1 and J-2).

SENDY first reads in commands (compare case n_1 with case n_2) and headings. Then it searches through the tape and locates the matrix whose headings match the one desired. After reading from tape, storing and printing out the matrix from each of the two cases, the arithmetical calculation on the two matrices is performed. After these calculations, the whole loop is repeated if requested (see Figure J-1).

DDSENDY is an integral part of SENDY consisting of the data set definition statements and the statements STOP/END. The data set reference number in the DD statement is made to be identical with the case number which was stored on the tape volume as addressed in the DD statement.

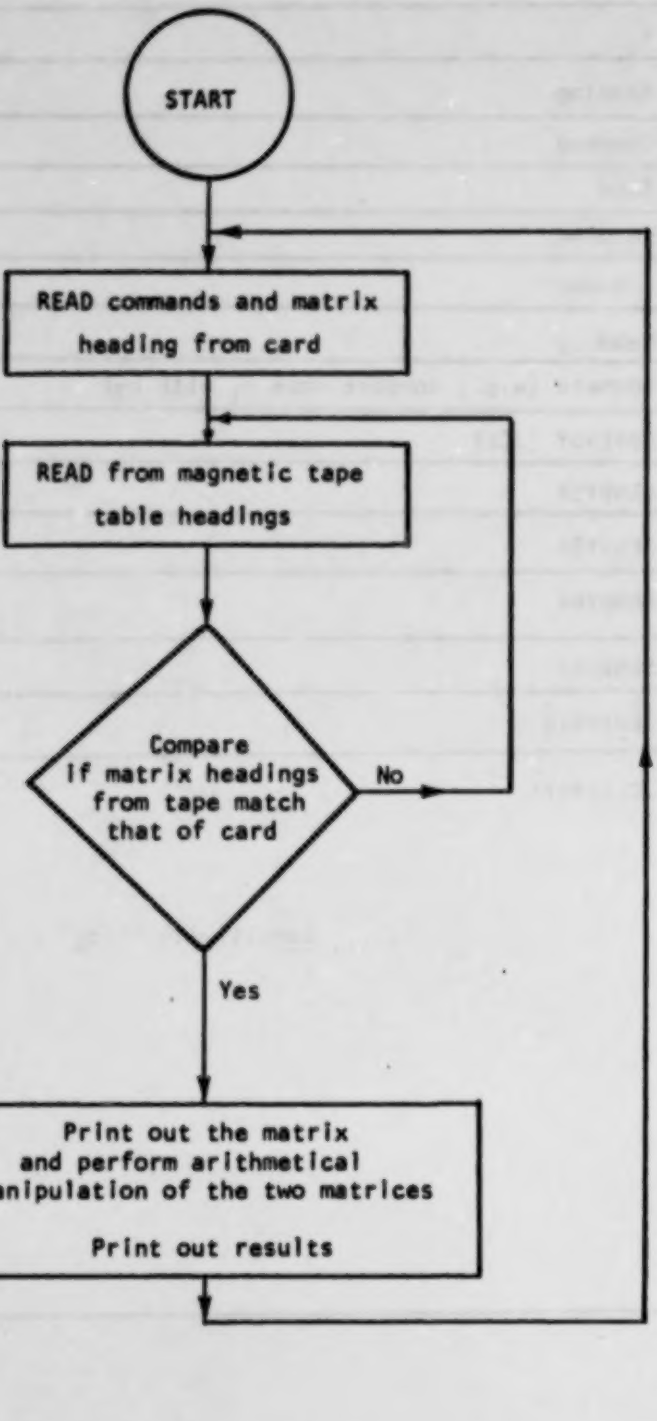
START
READ commands and matrix heading from card
READ from magnetic tape table headings
Compare if matrix headings from tape match that of card
No
Yes
Print out the matrix and perform arithmetical manipulation of the two matrices
Print out results

Figure J-1. SENDY simplified flowchart.

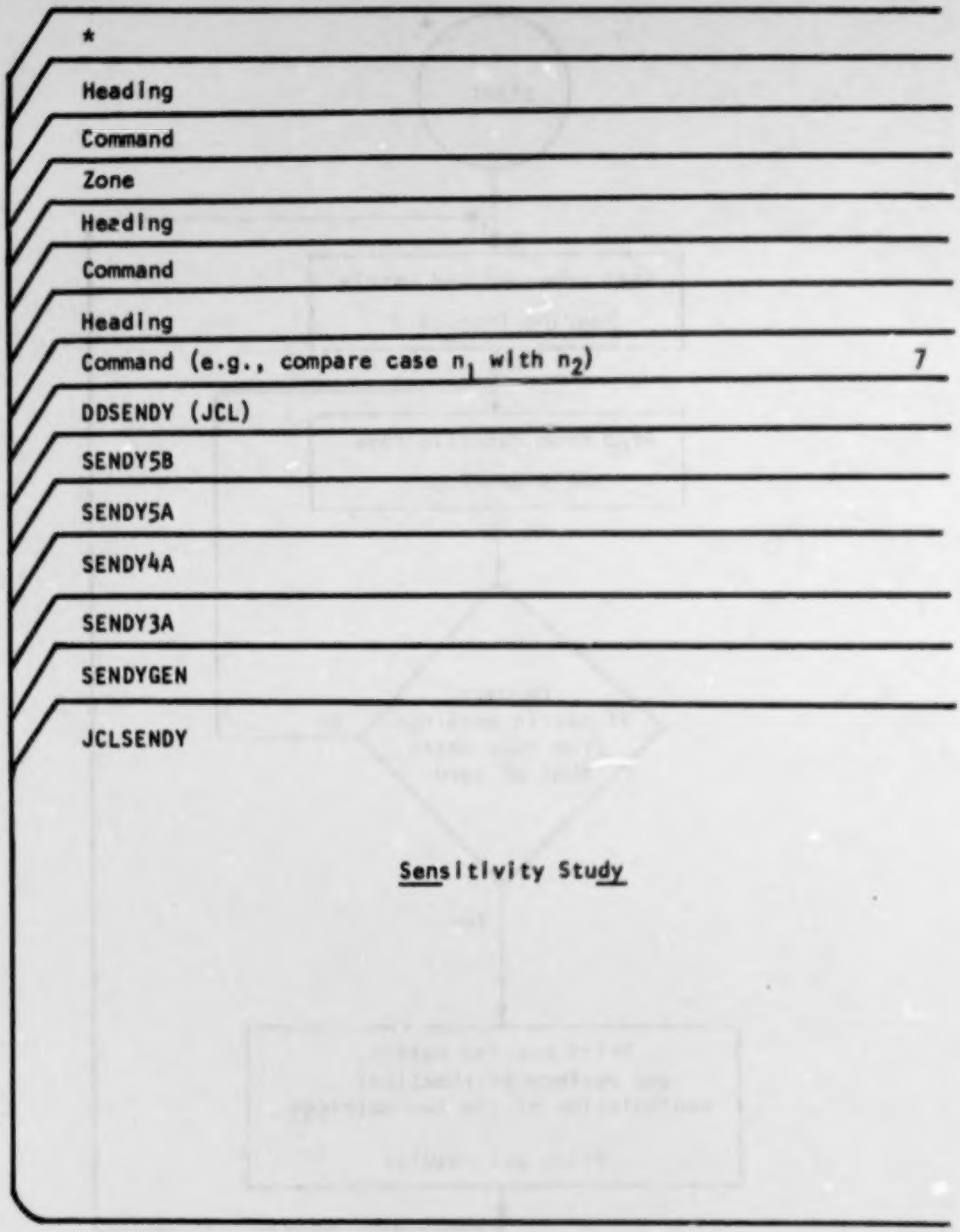
*
Heading
Command
Zone
Heading
Command
Heading
Command (e.g., compare case n_1 with n_2)
7
DDSENDY (JCL)
SENDY5B
SENDY5A
SENDY4A
SENDY3A
SENDYGEN
JCLSENDY
Sensitivity Study

Figure J-2. SENDY operating deck setup.

Description of Card Input. One card of each type is required.

Card Type	Format and Item	Description
1	FORMAT (10A4, I2, 2A4, A3, I2, T79, I2)	Commands
	EXPLAN(I)	Compare case n_1 with n_2.
	IP1	In column 41; first case number to compare (n_1).
	IP2	In column 54; second case number to compare (n_2).
	IMATH	Column 80, flags that control calculations options: IMATH Operation: 1 Normalized for case n_1. 2 Normalized for case n_2. 3 Normalized for case n_1 and n_2. 4 Dummy (for modification). 5 Dummy (for modification). 6 Dummy (for modification). 7 Ratio: first case, n_1, divided by second case, n_2.
2	FORMAT (17A4, A2, T77, A2, I1, A1)	Heading
	TITLE(I)	Store the heading of the desired matrix from card; column 1 to column 70.
	ISECT(3)	Section of output; column 77, 78.
	ISECT3	A code to aid in locating the matrix on tape: column 79, for ISECT3 (integer 3, 4, or 5 for AMRAW-A output section).
	CODE	Flag A or B in column 80. ISECT(3), ISECT3, and CODE appear on card as follows:

Section	AMRAW-A Item	
3	Local Dose, MAN1L	b33A
4	Nonspecific Dose, MAN1N	b44A
5	Local Dose, MAN2L	b55A
5	Nonspecific Dose, MAN2NF	b55B

Card Type	Format and Item	Description
3	FORMAT (T6, IZ)	Zone heading
	IZ	Additional table identifier where needed. Zone number as appeared on the left hand side of output pages: 1, 3, 5, or 7. Card required only for MAN2L from AMRAW-A with present output format.

Modification of SENDY. Calculation options may be added. Replace a CONTINUE statement by the mathematical routine desired. The matrix of the first case read in is stored in the variable that begins with an X in front of the original variable name. The second case is stored as the original variable name. The original variable with a Y in front can be used to store intermediate results. For example, SENDY4A deals with the variable MAN1N. The matrix from the first case is stored in XMAN1N, and from the second case as MAN1N. Variable YMAN1N is used to store intermediate results.

Statement numbers in each section of SENDY containing dummy "CONTINUE" statements and the corresponding IMATH flag are as follows:

	SENDY SECTION			
IMATH	3A	4A	5A	5B
4	2431	2535	2632	2732
5	2441	2545	2642	2742
6	2451	2555	2652	2752

Listing. Table J-2 presents the SENDY listing.

Sample Input. Sample input for a simple application of SENDY for comparison of nonspecific dose rates (AMRAW-A Section 3) from C-14 is presented. The comparison requested is to divide each value in the table from Case 55 by the corresponding value in the table from Case 48 (IMATH = 7) and output the resulting table of quotients. The input required is as follows:

```
                                                                   Column|80
                                                                         |
 ** SENSITIVITY ANALYSIS : COMPARE CASE 55 WITH CASE 48.                  7
NONSPECIFIC ... NUCLIDE=    C-14  K=  1                                 44A
```

Table J-2 (a). File SENDYGEN

```
      REAL X(3,4,50),XR1J(4,50),XR2TOT(4,50,8)
      REAL Y(3,4,50),YR1J(4,50),YR2TOT(4,50,8)
      REAL R(3,4,50),R1J(4,50),R2TOT(4,50,8)
      REAL XMANIL(50,8),YMANIL(50,8),MANIL(50,8)
      REAL TIME(50)
      REAL XMANIN(50,8),XAN2LF(50,8,4),XMAN2L(50,8),XAN2NF(50,4),
     CXMAN2N(50)
      REAL YMANIN(50,8),YAN2LF(50,8,4),YMAN2L(50,8),YAN2NF(50,4),
     CYMAN2N(50)
      REAL MANIN(50,8),MAN2LF(50,8,4),MAN2L(50,8),MAN2NF(50,4),MAN2N(50)
      EQUIVALENCE (X(1),XR1J(1),XR2TOT(1),XMANIL(1),XMANIN(1),XAN2LF(1),
     CXAN2NF(1)),(XMAN2L(1),XMAN2N(1))
      EQUIVALENCE (Y(1),YR1J(1),YR2TOT(1),YMANIL(1),YMANIN(1),YAN2LF(1),
     CYAN2NF(1)),(YMAN2L(1),YMAN2N(1))
      EQUIVALENCE (R(1),R1J(1),R2TOT(1),MANIL(1),MANIN(1),MAN2LF(1),MAN2
     CNF(1)),(MAN2L(1),MAN2N(1))
      INTEGER*4 JN(9),VAR(5),TITLE(17),CHECK(33),SECT(3),EXPLAN(15),IY,
     CIP1,IP2,IP1F,MT,IP,IN,MJ(4)
      DATA VAR/'0F10','.0,I','5,1P','9E1','2.2'/
      DATA JN/'1E1','2E1','3E1','4E1','5E1','6E1','7E1','8E1','9E1'/
      DATA MJ/3,3,3,1/
      DATA A,B,C/'A','B','C'/
      DATA SECT(1),SECT(2)/'SECT','ION '/
      IN=5
      IP=6
      MT=50
      MJF=4
      MIN=5
      TWASTE=187000.00
C     UNM COMPUTER SYSTUM ASSIGN DATA SET REFERENCE NUIMBER:
C     5 FOR CARD READER,6 FOR PRINTER.
C*****READ INPUT COMMAND & DETERMINE CASES TO COMPARE WITH. *******************
    1 READ(IN,1100,ERR=9990,END=9990)(EXPLAN(I),I=1,10),IP1,(EXPLAN(I),I
     C=11,13),IP2,IMATH
      IP1F=IP1
      WRITE(IP,1101)(EXPLAN(I),I=1,10),IP1,(EXPLAN(I),I=11,13),IP2
      IY=0
      READ(IN,1102)(TITLE(I),I=1,18),SECT(3),ISECT3,CODE
    2 IY=IY+1
      IF(IY.EQ.2) IP1=IP2
      GO TO (20,20,30,40,50),ISECT3
   20 READ(IP1,1103)
   80 DO 11 J=1,900
      READ(IP1,1104)(CHECK(I),I=16,18)
      WRITE(IP,1104)(CHECK(I),I=16,18)
      IF(CHECK(16).EQ.SECT(1).AND.CHECK(17).EQ.SECT(2).AND.CHECK(18).EQ.
     CSECT(3)) GO TO 2050
   11 CONTINUE
      WRITE(IP,1105)(TITLE(I),I=1,18)
      IF(ISECT3.EQ.2.AND.CODE.EQ.C) READ(IN,1100) DUMMY
      IF(ISECT3.EQ.5.AND.CODE.EQ.A) READ(IN,1100) DUMMY

      GO TO 1
   30 READ(IP1,1106)
      GO TO 80
   40 READ(IP1,1107)
      GO TO 80
   50 READ(IP1,1113)
      GO TO 80
 2050 READ(IP1,1108)
      IF(ISECT3.EQ.2.AND.CODE.EQ.A) GO TO 2100
      IF(ISECT3.EQ.2.AND.CODE.EQ.B) GO TO 2200
      IF(ISECT3.EQ.2.AND.CODE.EQ.C) GO TO 2300
      IF(ISECT3.EQ.3.AND.CODE.EQ.A) GO TO 2400
      IF(ISECT3.EQ.4.AND.CODE.EQ.A) GO TO 2500
      IF(ISECT3.EQ.5.AND.CODE.EQ.A) GO TO 2600
      IF(ISECT3.EQ.5.AND.CODE.EQ.B) GO TO 2700
 1100 FORMAT(10A4,I2,2A4,A3,I2,T79,I2)
 1101 FORMAT(1H1,10A4,I2,2A4,A3,I2)
 1102 FORMAT(17A4,A2,T77,A2,I1,A1)
 1103 FORMAT(4(255(/)),27(/))
 1104 FORMAT(1X,T61,2A4,A2)
 1105 FORMAT(1H1,'** OUTPUT MATRIX OF 1',18A4,' CANNOT BE FOUND.'//' CHE
     CCK STATEMENT NUMBER 10,20 OR 30.'/)
 1106 FORMAT(51(255(/)),54(/))
 1107 FORMAT(95(255(/)),95(/))
 1108 FORMAT(29(/))
 1109 FORMAT(1H1,'RATIO OF TWO OUTPUT MATRIXES',/' CASE',I4,' DIVIDED BY
     C CASE',I4/1X,'**IN THIS MATRIX, THE ELEMENTS ARE RATIO OF CORRE',
     C'SPONDING ELEMENTS IN THE PRECEEDING TWO MATRIXES'/' -1.00 STANDS
     CFOR ZERO DIVIDED BY ZERO. -X STANDS FOR X DIVIDED BY ZERO',
     C/2H0(,17A4,A2,1H))
 1110 FORMAT(1X,33A4)
 1111 FORMAT(33A4)
 1112 FORMAT(1H1,'INITIAL TOTAL INVENTORY OF WASTE=',F12.2,' METRIC TON'
     C/1X,17A4,A2,4X,'CASE',I4,/' NORMALIZED DOSE .'///)
 1113 FORMAT(101(255(/)),28(/))
```

Table J-2 (b). File SENDY3A

```
C************************************3A*************************************
C       READ MATRIX HEADINGS FROM TAPE.
  2400 DO 2406 K=1,2
       READ(IP1,1111)(CHECK(I),I=1,33)
  2406 WRITE(IP,1111)(CHECK(I),I=1,33)
  2410 READ(IP1,1110)(CHECK(I),I=1,7)
       DO 2420 I=1,7
       IF(CHECK(I).NE.TITLE(I)) GO TO 2430
  2420 CONTINUE
       WRITE(IP,1241)(TITLE(I),I=1,7),IP1
       DO 2407 K=1,3
       READ(IP1,1110)(CHECK(I),I=1,33)
  2407 WRITE(IP,1110)(CHECK(I),I=1,33)
       IF(IY.EQ.2) GO TO 2440
C      OUTPUT THE MATRIX FROM FIRST CASE FOR COMPARISON.
       DO 2450 IT=1,MT
  2450 READ(IP1,1242) TIME(IT),(XMAN1L(IT,IH),IH=1,MIH)
       REWIND IP1
       DO 2460 IT=1,MT
  2460 WRITE(IP,1242)TIME(IT),(XMAN1L(IT,IH),IH=1,MIH)
       GO TO 2
C      OUTPUT MATRIX FROM SECOND CASE FOR COMPARISON.
  2440 DO 2470 IT=1,MT
       READ(IP1,1242)TIME(IT),(MAN1L(IT,IH),IH=1,MIH)
  2470 WRITE(IP,1242)TIME(IT),(MAN1L(IT,IH),IH=1,MIH)
       REWIND IP1
       GO TO (2411,2421,2411,2431,2441,2451,2461),IMATH
  2411 IF(IMATH.NE.1.AND.IMATH.NE.3) GO TO 2421
       WRITE(IP,1112) TWASTE,(TITLE(I),I=1,17),IP1F
       DO 2412 IT=1,MT
       DO 2413 IH=1,MIH
  2413 YMAN1L(IT,IH)=XMAN1L(IT,IH)/TWASTE
  2412 WRITE(IP,1242) TIME(IT),(YMAN1L(IT,IH),IH=1,MIH)
  2421 IF(IMATH.NE.2.AND.IMATH.NE.3) GO TO 2431
       WRITE(IP,1112) TWASTE,(TITLE(I),I=1,17),IP2
       DO 2422 IT=1,MT
       DO 2423 IH=1,MIH
  2423 YMAN1L(IT,IH)=MAN1L(IT,IH)/TWASTE
  2422 WRITE(IP,1242) TIME(IT),(YMAN1L(IT,IH),IH=1,MIH)
  2431 CONTINUE
  2441 CONTINUE
  2451 CONTINUE
C      CALCULATE THE RATIO OF TWO MATRIXES.
  2461 DO 2480 IT=1,MT
       DO 2490 IH=1,MIH
       IF(MAN1L(IT,IH).NE.0.0) GO TO 2490
       IF(XMAN1L(IT,IH).NE.0.0) XMAN1L(IT,IH)=1.0
       MAN1L(IT,IH)=-1.0
  2490 MAN1L(IT,IH)=XMAN1L(IT,IH)/MAN1L(IT,IH)
  2480 CONTINUE
C      PRINT THE RATIO MATRIX.
       WRITE(IP,1109) IP1F,IP2,(TITLE(I),I=1,17)
       DO 2491 IT=1,MT
  2491 WRITE(IP,1242) TIME(IT),(MAN1L(IT,IH),IH=1,MIH)
       GO TO 1
  2430 READ(IP1,1243)
       GO TO 2410
  1241 FORMAT(1X,7A4,T62,'CASE',I4)
  1242 FORMAT(0PF11.0,1P10E10.2)
  1243 FORMAT(54(/))
```

Table J-2 (c). File SENDY4A

```
C**************************************4A****************************************
C     READ MATRIX HEADINGS FROM TAPE.
 2500 DO 2506 K=1,2
      READ(IP1,1111)(CHECK(I),I=1,33)
 2506 WRITF(IP,1111)(CHECK(I),I=1,33)
 2530 READ(IP1,1110)(CHECK(I),I=1,33)
      DO 2510 I=1,10
      IF(CHECK(I).NE.TITLE(I)) GO TO 2520
 2510 CONTINUE
C     PRINT OUT HEADINGS
      WRITE(IP,1250)(CHECK(I),I=1,10),IP1
      DO 2521 J=1,3
      FEAD(IP1,1110)(CHECK(I),I=1,33)
 2521 WRITE(IP,1110)(CHECK(I),I=1,33)
      IF(IY.EQ.2) GO TO 2540
C     OUTPUT THE MATRIX FROM FIRST CASE FOR COMPARISON.
      DO 2550 IT=1,MT
 2550 READ(IP1,1251) TIME(IT),(XMANIN(IT,IH),IH=1,MIH)
      REWIND IP1
      DO 2551 IT=1,MT
 2551 WRITE(IP,1251) TIME(IT),(XMANIN(IT,IH),IH=1,MIH)
      GO TU 2
C     OUTPUT THE MATRIX FROM SECOND CASE FOR COMPARISON.
 2540 DO 2560 IT=1,MT
      READ(IP1,1251) TIME(IT),(MANIN(IT,IH),IH=1,MIH)
 2560 WRITE(IP,1251) TIME(IT),(MANIN(IT,IH),IH=1,MIH)
      FEWIND IP1
      GO TO (2515,2525,2515,2535,2545,2555,2565),IMATH
 2515 IF(IMATH.NE.1.AND.IMATH.NE.3) GO TO 2525
      WRITE(IP,1112) TWASTE,(TITLE(I),I=1,18),IP1F
      DO 2516 IT=1,MT
      DO 2517 IH=1,MIH
 2517 YMANIN(IT,IH)=XMANIN(IT,IH)/TWASTE
 2516 WRITE(IP,1251) TIME(IT),(YMANIN(IT,IH),IH=1,MIH)
 2525 IF(IMATH.NE.2.AND.IMATH.NE.3) GO TO 2535
      WRITE(IP,1112) TWASTE,(TITLE(I),I=1,18),IP2
      DO 2526 IT=1,MT
      DO 2527 IH=1,MIH
 2527 YMANIN(IT,IH)=MANIN(IT,IH)/TWASTE
 2526 WRITE(IP,1251) TIME(IT),(YMANIN(IT,IH),IH=1,MIH)
 2535 CONTINUE
 2545 CONTINUE
 2555 CONTINUE
C     CALCULATE THE RATIO OF TWO MATRIXES.
 2565 DO 2570 IT=1,MT
      DO 2580 IH=1,MIH
      IF(MANIN(IT,IH).NE.0.0) GO TO 2580
      IF(XMANIN(IT,IH).EQ.0.0) XMANIN(IT,IH)=1.0
      MANIN(IT,IH)=-1.0
 2580 MANIN(IT,IH)=XMANIN(IT,IH)/MANIN(IT,IH)
 2570 CONTINUE

C     PRINT THE FATIUO MATRIX.
      WRITF(IP,1109) IP1F,IP2,(TITLE(I),I=1,10)
      DO 2590 IT=1,MT
 2590 WFITE(IP,1251) TIME(IT),(MANIN(IT,IH),IH=1,MIH)
      GO TO 1
 2520 FEAD(IP1,1252)
      GO TO 2530
 1250 FORMAT(1X,10A4,T62,'CASE',I4)
 1251 FORMAT(F11.0,1P10E10.2)
 1252 FORMAT(54(/))
```

Table J-2 (d). File SENDY5A

```
C*************************************5A*************************************************
 2600 IF(IY.EQ.1) READ(IN,1261) IZA,IZB
      DO 2625 J=1,2
      READ(IP1,1111)(CHECK(I),I=1,33)
 2625 WRITE(IP,1111)(CHECK(I),I=1,33)
 2630 READ(IP1,1110)(CHECK(I),I=1,33)
 2610 DO 2620 I=1,17
      IF(CHECK(I).NE.TITLE(I)) GO TO 2640
 2620 CONTINUE
      WRITE(IP,1263)(CHECK(I),I=1,18),IP1
      READ(IP1,1110)(CHECK(I),I=1,33)
      WRITE(IP,1110)(CHECK(I),I=1,33)
 2631 READ(IP1,1262) IZ,IZP1
      IF(IZ.NE.IZA) GO TO 2650
      WRITE(IP,1264) IZ,IZP1
C     PRINT HEADINGS.
      DO 2660 J=1,4
      READ(IP1,1110)(CHECK(I),I=1,33)
 2660 WRITE(IP,1110)(CHECK(I),I=1,33)
      IF(IY.EQ.2) GO TO 2690
C     OUTPUT THE MATRIX FROM FIRST CASE FOR COMPARISON.
      DO 2670 IT=1,MT
 2670 READ(IP1,1265) TIME(IT),(XAN2LF(IT,IZ,JF),JF=1,MJF),XMAN2L(IT,IZ),
     CTIME(IT),(XAN2LF(IT,IZP1,JF),JF=1,MJF),XMAN2L(IT,IZP1)
      REWIND IP1
      DO 2680 IT=1,MT
 2680 WRITE(IP,1265) TIME(IT),(XAN2LF(IT,IZ,JF),JF=1,MJF),XMAN2L(IT,IZ),
     CTIME(IT),(XAN2LF(IT,IZP1,JF),JF=1,MJF),XMAN2L(IT,IZP1)
      GO TO 2
C     OUTPUT THE MATRIX FROM SECOND CASE FOR COMPARISON.
 2690 DO 2691 IT=1,MT
 2691 READ(IP1,1265) TIME(IT),(MAN2LF(IT,IZ,JF),JF=1,MJF),MAN2L(IT,IZ),
     CTIME(IT),(MAN2LF(IT,IZP1,JF),JF=1,MJF),MAN2L(IT,IZP1)
      WRITE(IP,1265)(TIME(IT),(MAN2LF(IT,IZ,JF),JF=1,MJF),MAN2L(IT,IZ),
     CTIME(IT),(MAN2LF(IT,IZP1,JF),JF=1,MJF),MAN2L(IT,IZP1),IT=1,MT)
      REWIND IP1
      GO TO (2612,2622,2612,2632,2642,2652,2662),IMATH
 2612 IF(IMATH.NE.1.AND.IMATH.NE.3) GO TO 2622
      WRITE(IP,1112) TWASTE,(TITLE(I),I=1,18),IP1F
      DO 2613 IT=1,MT
      DO 2614 JF=1,MJF
      YAN2LF(IT,IZ,JF)=XAN2LF(IT,IZ,JF)/TWASTE
 2614 YAN2LF(IT,IZP1,JF)=XAN2LF(IT,IZP1,JF)/TWASTE
      YMAN2L(IT,IZ)=XMAN2L(IT,IZ)/TWASTE
      YMAN2L(IT,IZP1)=XMAN2L(IT,IZP1)/TWASTE
 2613 WRITE(IP,1265) TIME(IT),(YAN2LF(IT,IZ,JF),JF=1,MJF),YMAN2L(IT,IZ),
     CTIME(IT),(YAN2LF(IT,IZP1,JF),JF=1,MJF),YMAN2L(IT,IZP1)
 2622 IF(IMATH.NE.2.AND.IMATH.NE.3) GO TO 2632
      WRITE(IP,1112) TWASTE,(TITLE(I),I=1,18),IP2
      DO 2623 IT=1,MT
      DO 2624 JF=1,MJF

      YAN2LF(IT,IZ,JF)=MAN2LF(IT,IZ,JF)/TWASTE
 2624 YAN2LF(IT,IZP1,JF)=MAN2LF(IT,IZP1,JF)/TWASTE
      YMAN2L(IT,IZ)=MAN2L(IT,IZ)/TWASTE
      YMAN2L(IT,IZP1)=MAN2L(IT,IZP1)/TWASTE
 2623 WRITE(IP,1265) TIME(IT),(YAN2LF(IT,IZ,JF),JF=1,MJF),YMAN2L(IT,IZ),
     CTIME(IT),(YAN2LF(IT,IZP1,JF),JF=1,MJF),YMAN2L(IT,IZP1)
 2632 CONTINUE
 2642 CONTINUE
 2652 CONTINUE
C     CALCULATE THE RATIO OF TWO MATRIXES.
 2662 DO 2695 IT=1,MT
      DO 2697 JF=1,MJF
      IF(MAN2LF(IT,IZ,JF).NE.0.0) GO TO 269
      IF(XAN2LF(IT,IZ,JF).EQ.0.0) XAN2LF(IT,IZ,JF)=1.0
      MAN2LF(IT,IZ,JF)=-1.0
  269 MAN2LF(IT,IZ,JF)=XAN2LF(IT,IZ,JF)/MAN2LF(IT,IZ,JF)
      IF(MAN2LF(IT,IZP1,JF).NE.0.0) GO TO 2696
      IF(XAN2LF(IT,IZP1,JF).EQ.0.0) XAN2LF(IT,IZP1,JF)=1.0
      MAN2LF(IT,IZP1,JF)=-1.0
 2696 MAN2LF(IT,IZP1,JF)=XAN2LF(IT,IZP1,JF)/MAN2LF(IT,IZP1,JF)
 2697 CONTINUE
      IF(MAN2L(IT,IZ).NE.0.0) GO TO 270
      IF(XMAN2L(IT,IZ).EQ.0.0) XMAN2L(IT,IZ)=1.0
      MAN2L(IT,IZ)=-1.0
  270 MAN2L(IT,IZ)=XMAN2L(IT,IZ)/MAN2L(IT,IZ)
      IF(MAN2L(IT,IZP1).NE.0.0) GO TO 271
      IF(MAN2L(IT,IZP1).EQ.0.0) XMAN2L(IT,IZP1)=1.0
      MAN2L(IT,IZP1)=-1.0
  271 MAN2L(IT,IZP1)=XMAN2L(IT,IZP1)/MAN2L(IT,IZP1)
 2695 CONTINUE
C     PRINT THE RATIO MATRIX
      WRITE(IP,1109) IP1F,IP2,(TITLE(I),I=1,18)
      DO 2698 IT=1,MT
 2698 WRITE(IP,1265) TIME(IT),(MAN2LF(IT,IZ,JF),JF=1,MJF),MAN2L(IT,IZ),
     CTIME(IT),(MAN2LF(IT,IZP1,JF),JF=1,MJF),MAN2L(IT,IZP1)
      GO TO 1
 2640 READ(IP1,1266)
      GO TO 2630
 2650 READ(IP1,1267)
      GO TO 2631
 1261 FORMAT(T6,I2,T79,I2)
 1262 FORMAT(T8,I2,T76,I2)
 1263 FORMAT(1X,18A4,T76,'CASE',I4)
 1264 FORMAT(2X,'ZONE=',I2,T71,'ZONE=',I2)
 1265 FORMAT(0PF9.0,1P5E10.2,1X,0PF9.0,1P5E10.2)
 1266 FORMAT(234(/))
 1267 FORMAT(57(/))
```

Table J-2 (e). File SENDY5B

```
C****************************************5D**************************************
C       SKIP 1887 RECORDS AND READ HEADINGS CF MATRIX FROM TAPE.
  2700 READ(IP1,1270)
       DO 2729 J=1,2
       READ(IP1,1111)(CHECK(I),I=1,33)
  2729 WRITE(IP,1111)(CHECK(I),I=1,33)
  2730 READ(IP1,1110)(CHECK(I),I=1,33)
       DO 2710 I=1,17
       IF (CHECK(I).NE.TITLE(I)) GO TO 2720
  2710 CONTINUE
C      PRINT HEADINGS.
       WRITE(IP,1271)(CHECK(I),I=1,18),IP1
       DO 2711 K=1,4
       READ(IP1,1110)(CHECK(I),I=1,33)
  2711 WRITE(IP,1110)(CHECK(I),I=1,33)
       IF(IY.EQ.2) GO TO 2740
C      OUTPUT THE MATRIX FROM FIRST CASE FOF COMPARISON.
       DU 2750 IT=1,MT
  2750 READ(IP1,1272) TIME(IT),(XAN2NF(IT,JF),JF=1,MJF),XMAN2N(IT)
       REWIND IP1
       DO 2760 IT=1,MT
  2760 WRITE(IP,1272) TIME(IT),(XAN2NF(IT,JF),JF=1,MJF),XMAN2N(IT)
       GO TO 2
C      CUTPUT THE MATRIX FROM SECOND CASE FOR COMPAPISUN.
  2740 DO 2770 IT=1,MT
       READ(IP1,1272) TIME(IT),(MAN2NF(IT,JF),JF=1,MJF),MAN2N(IT)
  2770 WRITE(IP,1272) TIME(IT),(MAN2NF(IT,JF),JF=1,MJF),MAN2N(IT)
       REWIND IP1
       GO TO (2712,2722,2712,2732,2742,2752,2762),IMATH
  2712 IF(IMATH.NE.1.AND.IMATH.NE.3) GO TO 2722
       WRITE(IP,1112) TWASTE,(TITLE(I),I=1,18),IP1F
       DU 2713 IT=1,MT
       DO 2714 JF=1,MJF
  2714 YAN2NF(IT,JF)=XAN2NF(IT,JF)/TWASTE
       YMAN2N(IT)=XMAN2N(IT)/TWASTE
  2713 WRITE(IP,1272) TIME(IT),(YAN2NF(IT,JF),JF=1,MJF),YMAN2N(IT)
  2722 IF(IMATH.NC.2.AND.IMATH.NE.3) GO TO 2732
       WRITE(IP,1112)TWASTE,(TITLE(I),I=1,16),IP2
       DO 2723 IT=1,MT
       DO 2724 JF=1,MJF
  2724 YAN2NF(IT,JF)=MAN2NF(IT,JF)/TWASTE
       YMAN2N(IT)=MAN2N(IT)/TWASTE
  2723 WRITE(IP,1272) TIME(IT),(YAN2NF(IT,JF),JF=1,MJF),YMAN2N(IT)
  2732 CONTINUE
  2742 CONTINUE
  2752 CONTINUE
C      CALCULATE THE RATIO OF TWO MATRIXES.
  2762 DO 2780 IT=1,MT
       DO 2790 JF=1,MJF
       IF(MAN2NF(IT,JF).NE.0.0) GO TO 2790
       IF(XAN2NF(IT,JF).EQ.0.0) XAN2NF(IT,JF)=1.0

       MAN2NF(IT,JF)=-1.0
  2790 MAN2NF(IT,JF)=XAN2NF(IT,JF)/MAN2NF(IT,JF)
       IF(MAN2N(IT).NE.0.0) GO TO 279
       IF(XMAN2N(IT).EQ.0.0) XMAN2N(IT)=1.0
       MAN2N(IT)=-1.0
   279 MAN2N(IT)=XMAN2N(IT)/MAN2N(IT)
  2780 CONTINUE
C      PRINT OUT THE RATIO MATRIX.
       WRITE(IP,1109) IP1F,IP2,(TITLE(I),I=1,18)
       DO 2791 IT=1,MT
  2791 WRITE(IP,1272) TIME(IT),(MAN2NF(IT,JF),JF=1,MJF),MAN2N(IT)
       GO TO 1
  2720 READ(IP1,1273)
       GO TO 2730
  1270 FORMAT(7(255(/)),102(/))
  1271 FORMAT(1X,18A4,T76,'CASE',I4)
  1272 FORMAT(F12.0,1P5E10.2)
  1273 FORMAT(55(/))
```

Table J-2 (f). File DDSENDY (i.e., JCL)

```
1000   9990 STOP
1010        END
1020 //GO.FT48F001 DD UNIT=TAPE9,DSN=EPAJOB,VOL=SER=PE1737,
1030 // LABEL=(1,SL),DCB=(RECFM=FBA,LRECL=133,BLKSIZE=1330),
1040 // DISP=(OLD,PASS)
1080 //GO.FT55F001 DD UNIT=TAPE9,DSN=EPAJOB,VOL=SER=PE1737,
1090 // LABEL=(3,SL),DCB=(RECFM=FBA,LRECL=133,BLKSIZE=1330),
1100 // DISP=(OLD,PASS)
1110 //GO.SYSIN DD *
```

PART 2

AMRAW-B USERS' GUIDE

CHAPTER 6. SUMMARY
CHAPTER 7. INPUT/OUTPUT DESCRIPTION
CHAPTER 8. PROGRAM OPTIONS
CHAPTER 9. ERROR MESSAGES

APPENDICES: K THROUGH T

CHAPTER 6

SUMMARY

A. PROGRAM SUMMARY

Title: AMRAW-B; Assessment Method for Radioactive Waste (Second Part).

Abstract: AMRAW-B performs a sequence of calculations for an inventory of radioactive wastes, evaluating health effects and economic costs resulting from dose to man calculated by AMRAW-A.

Effective Date: May, 1978.

Programmer: The University of New Mexico staff.

Computer: IBM 360/67.

Language: Fortran IV.

Core Memory Requirement: 124 k bytes.

Execution Time (CP sec): 270.

Auxiliary Hardware Requirements: Disk, Tape, Line Printer.

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B. PURPOSE

AMRAW-B, the second part of the Radioactive Waste Management Systems Model, picks up the population dose rates calculated in AMRAW-A and calculates corresponding estimates of health effects and economic costs of these health effects (see Fig. 1-2). These calculations consider the populations in each geographic zone, incidence rates of health effects per unit of radiation dose to a given body organ, and costs based upon the value of small changes in risk.

C. METHOD

The AMRAW Code is written in Fortran IV language. The two parts of the code are: 1) AMRAW-A which contains the Source Term, the Release Model, and the Environmental Model, and 2) AMRAW-B which contains the Economics Model. They are being run separately but may be joined if desired. There is an advantage to running the first part independently to determine sensitivity of environmental concentrations and dose rates to variations in input. Similarly, there is an advantage to running the economic model independently to study the response to varied economic parameters.

The flow of AMRAW-B calculations is best described first using the sequence indicated by Fig. 1-2: 1) determine rate of occurrence of health effects, and 2) perform corresponding damage calculations in economic units. An altered sequence of the actual calculations within AMRAW-B is then described. The matrix of local dose rates from AMRAW-A, to individuals in each zone from each radionuclide to each body site (organ) during each time increment, multiplied by the population of each zone and then multiplied by the set of health effect incidence rates for each body site, obtains the health effect incidence rates in each zone. Similarly, nonspecific dose rates from AMRAW-A (dose to a nonspecific population) multiplied by health effect incidence rates obtains health effect incidence rates corresponding to nonspecific dose. As actually calculated within AMRAW-B, the input incidence rates of health effects, deaths/10^6 man-rem, are first converted to \$/man-rem by multiplying by \$260,000/10^6 (the value \$260,000 is the present input for cost of increased level of risk, VOL). Damage rates, \$/y, in each zone (and the nonspecific category), are calculated by multiplying together: dose rates, populations, and \$/man-rem. The damage rates, \$/y, are accumulated over nuclides and organs in each zone (and nonspecific) versus time. Total damage rates are also accumulated over zones, organs, and times for each nuclide. Damages during each time increment, \$, are then obtained by multiplying rates by the length of each time increment and accumulated over the total time range. Finally, the number of deaths (health effects) during each time increment are obtained by dividing the damages in dollars by \$260,000. Results are obtained for both high and low population projections.

The present dimensioning of AMRAW-B is as follows:

1) Radionuclides: 25.

2) Geographic Zones: 8 (the nonspecific category is treated as a ninth zone in calculations).

3) Human Organs: 8; typically, one of these is total body.

4) Time Increments: 50.

AMRAW-B runs with 124 k bytes of core storage, 125 tracks (900 k bytes) of disk storage for input data, 10 cylinders (200 tracks or 1440 bytes) of disk storage for intermediate storage, and requires 270 seconds of CPU time in the UNM IBM 360/67 computer. Input data from the major data matrices can be furnished from tape instead of from disk if preferred.

CHAPTER 7

INPUT/OUTPUT DESCRIPTION

Input for AMRAW-B is by an 80 column card data deck. There are 15 card types. As implemented at UNM, the input deck is read from 3 files in disk and/or tape storage. No additional inputs are required. The 3 input data files are as follows:

1) AMB. This file provides economic model control and conversion data, including discount rate (zero presently used), cost assigned to a death, the numbers of times, zones, radionuclides, and organs involved, incidence rates of health effects by body site or organ, high and low population projections by zone, and designation of nuclide decay group.

2) AM1E. This file provides values of time at the end of each time increment, names of each radionuclide, and the mass of each radionuclide (in grams) in the repository inventory at each time.

3) ECONxx (xx is case number). This is the large output matrix, MAN1, of dose rates from AMRAW-A, restructured for AMRAW-B input.

Radionuclide mass versus time is used within AMRAW-B at this time only for calculation of marginal damages ($/gram) by decay group, based upon the accumulated inventory at the time repository operations cease. The full nuclide matrix provides for possible additions to AMRAW-B for allocation of damages to elements in the waste. The dose rate matrix, MAN1, from AMRAW-A is arranged as shown in Table 7-1. With the present dimensioning used, the dose rates are presented in 225 separate tables (9 zones x 25 nuclides). For input to AMRAW-B, this is processed through an auxiliary program, COMPRESS, to strip away headings and the time column, producing a data file with 11,250 lines (from 225 tables x 50 lines each). Each line has dose rate values for 8 organs resulting in 90,000 data items.

Card input is described in the following section. Output is described in Section 7.B.

Table 7-1. Arrangement of AMRAW-A Dose Rate Output: Local Dose Rate by Zone and Nonspecific Dose Rate

```
Zone 1[a]
    Nuclide 1
        Time Increment 1:  Organ 1, Organ 2, ... Organ 8.[b]
                       2:  Organ 1, Organ 2, ... Organ 8.
                       (repeat for other time increments)
                       .
                       .
                       .
                      50:  Organ 1, Organ 2, ... Organ 8.
    Nuclide 2
        (repeat for other nuclides)
        .
        .
        .
    Nuclide 25
Zone 2
    (repeat for other zones)
    .
    .
    .
Zone 8

Nonspecific (handled as Zone 9).[c]
```

---

[a] Local dose rates are mrem/y.

[b] Organ refers to each body site for which dose rate is calculated.

[c] Nonspecific dose rates are man-rem/y.

A. CARD INPUT SPECIFICATIONS

1. Data Deck Setup. Descriptions and number required of each card type are given in section 2 which follows. The sequence of the data deck, beginning with the first or front card is listed below:

File	Card Type	Items
AMB	1	TITLE
	2	RATE
	3	VOL
	4	NT
	5	NZ
	6	NK
	7	NINT
	8	SITE, DPY
	9	REG, POPH, POPL
	10	NG
	11	K, IKK
AM1E	12	TIME
	13	NUCNAM, X
	14	X
ECONxx	15	MAN1

2. Description of Card Input. Input data is grouped into 3 sequentially read data files: AMB, AM1E, and ECONxx (where xx denotes the case number from which this file is extracted).

The largest matrix of data is for MAN1 (card type 12). This is the dose rate output from AMRAW-A as selected and restructured by auxiliary program COMPRESS for use as AMRAW-B input. As presently dimensioned, this file can consist of as many as 11,250 cards. Because of its size, this file is handled via tape and/or disk storage.

A list of each card type in input sequence, the necessary card format in each instance, the number of each card type required (one card unless stated otherwise), the data items and their descriptions, plus other explanatory notes are presented below.

The following card types 1 through 11 comprise data file AMB, economic model control and conversion data.

Card Type	Format and Items	Description
1.	FORMAT (10A4)	
	TITLE	Title of case, up to 40 characters.
2.	FORMAT (15X, F10.0)	
	RATE	Discount rate, expressed as decimal.
3.	FORMAT (15X, F10.0)	
	VOL	Cost of increased level of risk.
4.	FORMAT (20X, I5)	
	NT	Number of times.
5.	FORMAT (20X, I5)	
	MZ	Number of geographic zones.
6.	FORMAT (20X, I5)	
	NK	Number of nuclides.
7.	FORMAT (20X, I5)	
	NIHT	Number of organs (body sites).
8.	FORMAT (5A4, F5.0)	1 card for each of NIHT organs.
	SITE	Name of organ (body site), up to 20 characters.
	DPY	Health effect incidence rate, cases per 10^6 man-rem.
9.	FORMAT (A4, 1X, 2F10.0)	1 card for each of MZ zones.
	REG	Name of zone up to 4 characters
	POPH	High population projection.
	POPL	Low population projection.
10.	FORMAT (3X, 25I3)	
	NG	Number of nuclide decay groups.
11.	FORMAT (3X, 25I3)	1 card for each of NG groups.
	K	Number of nuclides in group.
	IKK(J)	Subscript identity of each of K nuclides in group.

The following card types 12 through 14 comprise data file AM1E which furnishes values of time to be calculated and the nuclide inventory versus time.

Card Type	Format and Items	Description
12.	FORMAT (1P8E10.2)	1 card for each 8 times of NT total.
	TIME(I)	Time in years for each subscripted value of TIME.

One set of the following card types 10 and 11 is required for nuclide K of NK total (e.g., for 25 nuclides and 50 time, 25 x 8 = 200 cards, are required).

13.	FORMAT (A8, 2X, 7E10.2)	1 card in each nuclide set.
	NUCNAM (K)	Abbreviated name of nuclide (e.g., SR 90 or AM 241M).
	X(K, IT)	Inventory quantities for first 7 times IT.
14.	FORMAT (10X, 7E10.2)	1 card for each 7 times, 8 through NT, in each nuclide group.
	X(K, IT)	Inventory quantities for times 8 through NT. This card bypasses rereading NUCNAM, which may be placed on each card along with card sequence number in the 10X field.

The following card type 15 comprises data file ECONxx (xx represents the case number from which the file is extracted). This file is the large matrix which is a portion of AMRAW-A output, providing calculated dose rates.

15.	FORMAT (1P8E10.2)	One set of cards for each Zone IZ of MZ + 1 total (the last "zone" is reserved for "nonspecific dose") (maximum MZ + 1 is 9) within each set is a subset of cards for each nuclide K of NK total (25 maximum), one card for each time 1 of NT total (50 maximum), (e.g., for 9 zones, including the nonspecific category, 25 nuclides, and 50 times, 9 x 25 x 50 = 11,250 cards, are required).
	MAN1 (IT, IH)	Dose rate to each organ IH of NIHT total (8 maximum), at time IT (in Zone IZ via nuclide K).

A sample coding form illustrating the first card of each type is given in Appendix M. More complete sample input is given in Appendix P.

B. OUTPUT DESCRIPTION

AMRAW-B requires two output mediums: disk and line printer.

1. Disk. Intermediate temporary storage of calculated values for each nuclide is on disk. Output can be to disk and/or line printer.

2. Line Printer. The line printer must be capable of 132 characters per line.

3. Output Tables. Output from AMRAW-B is the series of tables listed in the directory in Table 7-2. Table 1 as numbered by AMRAW-B provides average damage rates in each zone, for nonspecific, and the total, versus time. Subtables are for high and low population projections, respectively. Table 2 is a series of tables, one for each time increment giving average damage rates: total for zones, nonspecific, and total by nuclide, for high and low population. Table 3 presents the total discounted present value of damages over the entire time range for each nuclide, subtotals for each decay group and the overall total, for high and low populations. This table also includes marginal damages, by decay group and total, based upon masses in repository inventory at the beginning of the terminal storage phase. Table 4 presents total expected deaths per time interval in each zone, for nonspecific, and the total, versus time. Similarly, Table 5 presents total damages in dollars per time interval. Subtables of Tables 4 and 5 are for high and low populations. Sample output is given in Appendix P.

Table 7-2. Directory of AMRAW-B Output Tables

Table No.	Title or Description	Nuclides	Units				Components				Population	
			$/y	$/Δt[a]	$/$10^6$ y	Deaths/ Δt[a]	Each Zone	Total of zones	Non-specific	Total	High	Low
	Output listing of selected AMRAW-B input											
1-1	Zonal and Total Damages for High Population Projection, $/y.	Total	x				x	x	x	x	x	
1-2	Zonal and Total Damages for Low Population Projection, $/y.	Total	x				x	x	x	x		x
2	One table for each time interval calculated: damages by nuclide, $/y,	25 (1 table for each time interval-43)	x					x	x	x	x	x
3	Discounted Present Values, $, and $/g.	25			x					x	x	x
4-1	High Population Scenario: Number of Deaths Per Time Interval.	Total				x	x	x	x	x	x	
4-2	Low Population Scenario: Number of Deaths Per Time Interval.	Total				x	x	x	x	x		x
5-1	Total Undiscounted Damages for Each Zone for Each Time Interval-High Population, $.	Total		x			x	x	x	x	x	
5-2	Total Undiscounted Damages for Each Zone for Each Time Interval-Low Population, $.	Total		x			x	x	x	x		x

[a] Δt represents the length of time interval calculated.

CHAPTER 8

PROGRAM OPTIONS

The major class of options is concerned with design of the application. The number of nuclides, geographic zones, times, release scenarios, and environmental pathways may be varied in AMRAW-A within the range of dimensioning and carry over into the AMRAW-B calculations.

There are no options built into AMRAW-B for alternate calculation sequences. There is an option to print or suppress printing of output Table 2. This table consists of 1 page for each time calculated (see Table 2-2 for description). Setting ITB3 = 1 requests printing of output Table 2; setting ITB3 = 0 suppresses printing. Write statements are provided (before and after Format statement 3806) for outputting the large MAN1 input matrix from file ECONxx. The write statements are suppressed by labeling as comment statements. Removal of the "C" from the two lines results in output.

The input/output mediums are specified in statements in the main program which assign values for the variables IN, IP, and IS appropriate to the system being used:

IN	specifies an input medium, normally the card reader (at UNM, this is 5).
IP	specifies the output medium for the code; this is normally the line printer but it may be set to disk or tape file if preferred, along with appropriate JCL (at UNM, line printer is 6).
IS	specifies an input medium with large storage, used for file ECONxx. This can be disk or tape files; the value of IS can be any allowable and free integer as supported by appropriate JCL (at UNM, this may be 1, 3, or 4; 2 is used in AMRAW-B for system disk storage of intermediate calculations).

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CHAPTER 9

ERROR MESSAGES

AMRAW-B in the present version does not generate error messages. No such addition is planned at this point in time. If the computer code fails in a run, it is suggested that the input data formats be checked. Extensive comment statements have been placed in the program for assisting the user to isolate any problems.

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APPENDIX K

BACKGROUND MATERIAL

The basic structure of the AMRAW model and computer code was developed at UNM between 1972 and 1974 as part of the S. Logan Ph.D. dissertation: "A Technology Assessment Methodology Applied to High-Level Radioactive Waste Management," The University of New Mexico, 1974. Additional development proceeded with support from the Sandia Laboratories University Research Program and from the Energy Resources Board of the State of New Mexico. Completion of the model and code was done under EPA Contract No. 68-01-3256 beginning in August, 1975.

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APPENDIX L

SAMPLE RUN REQUEST

AMRAW-B RUN REQUEST

Requested By: ______________________________

Phone: ________________ Date: ________________

Number of Seconds: __________ No. of Ouput Lines: ______

Number of Copies Requested: __________

Special Form? __________ If so, form no. ____________

Input Data On: Disk __________ Disk Name: ____________

DSN: ____________

Card __________ Tape ________ Tape Name: ____________

Label: ________ DSN: ____________

- -

OFFICE USE ONLY

Date Received: ________________

Date Submitted: ________________

Date Returned: ________________

Initials: __________

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APPENDIX M

SAMPLE CODING FORM

Table M-1 presents a sample coding form for AMRAW-B input data illustrating proper formats for each of the 15 card types. The data shown is from the base case for terminal storage, reported elsewhere. Only the first card of each card type is illustrated. Card types 1 through 11 comprise data file AMB, card types 12 through 14 comprise data file AM1E and card type 15 represents the large dose rate output file from AMRAW-A: ECONxx. For 9 zones, including one "zone" allocated to non-specific dose rates, 25 nuclides, and 50 times, 11,250 cards of card type 15 are required. Because of the large size of the last file, it is obtained from AMRAW-A and placed on tape or disk by machine processing. File AM1E is obtained from an AMRAW-A input data file via machine processing. Normally, only file AMB requires key punching or typing on a terminal.

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Table M-1. Sample Coding Form with First Cards of Each Type Illustrated[a]

```
Card
Type  Card Column
 1  ECON48 - 50 PERIODS - NEW BODY COEFF.
 2  RATE[b]                0.0
 3  VOL              260000.0
 4  NT                     50
 5  MZ                      8
 6  NK                     25
 7  NIHT                    8
 8  TOTAL BODY (REMAIN.)   85
 9  REPO        101       101
10  NG 11
11  G01 2 19 25
12    0.00E+00  5.00E+00  1.00E+01  1.50E+01  2.00E+01  2.50E+01  3.00E+01  4.00E+01
13     C-14 1   0.0       6.14E+01  1.28E+03  4.07E+03  9.99E+03  2.17E+04  4.04E+04
14     C-14 2   4.04E+04  4.04E+04  4.03E+04  4.02E+04  4.02E+04  4.01E+04  4.01E+04
15         0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
```

[a] One card each of types 1 - 7 and 10 is required; more than 1 card is generally required for each of the other types.

[b] The variable name on card types 2 - 7 is not read.

APPENDIX N

JOB PROCESSING INSTRUCTIONS

1. Prepare jobcard for computer run using run request as follows:

   Job name - 8 alphanumeric characters.

   Time parameter - number of seconds estimated.

   Lines parameter - number of lines (in thousands) estimated.

   Forms parameter - form number from request.

   Copies parameter - number of copies requested.

2. Input medium:

   Card - keypunch as necessary and place in appropriate section of deck.

   Disk - modify the data definition statement GO.FT01F001 DD card to reflect parameters required by the system.

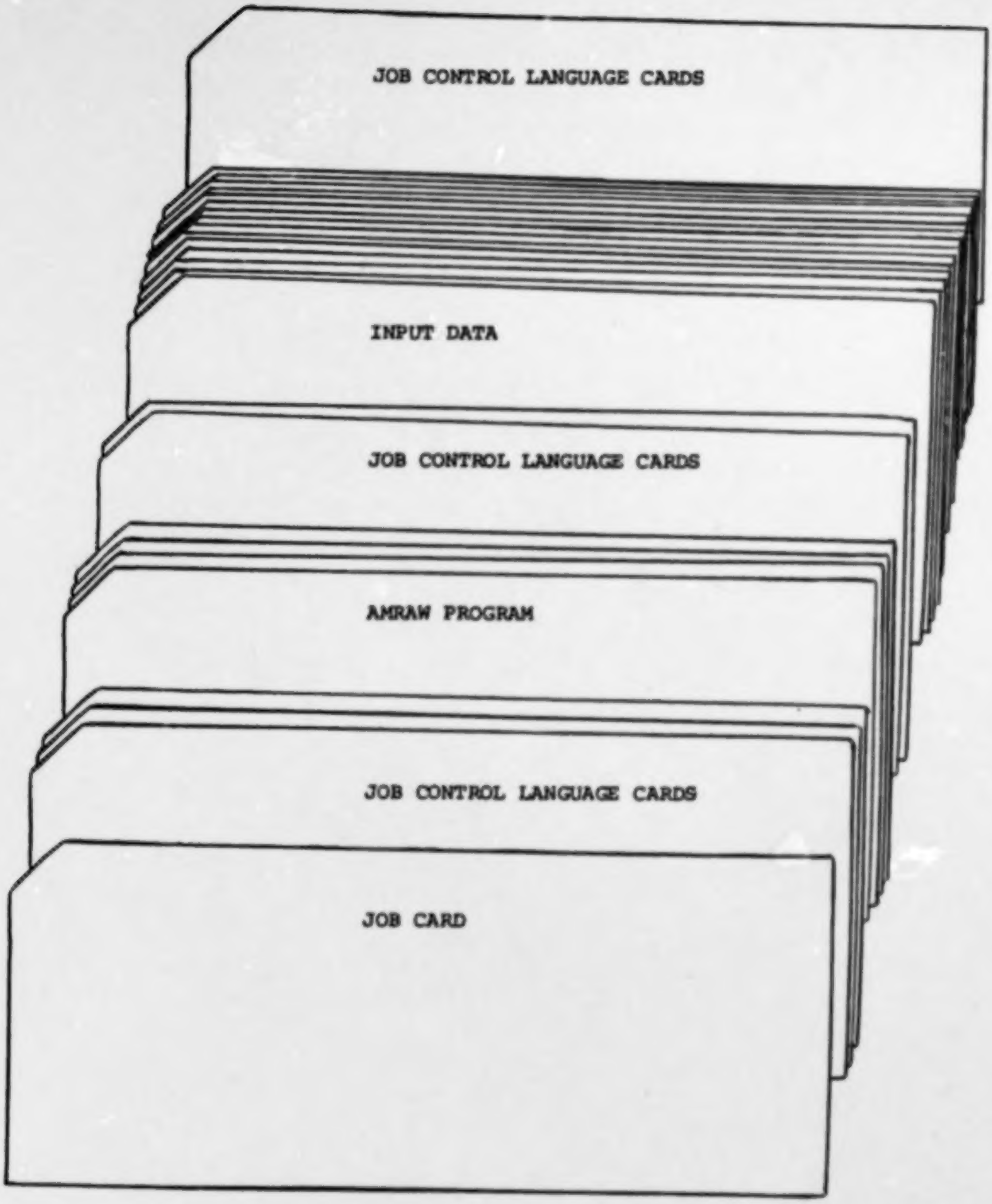
   Tape - modify the data definition statement GO.FT02F001 DD card to reflect parameters required by the system.

3. Submit job and note date submitted.

4. Return job to requester and note date returned.

APPENDIX O

OPERATING DECK SETUP


JOB CONTROL LANGUAGE CARDS
INPUT DATA
JOB CONTROL LANGUAGE CARDS
AMRAW PROGRAM
JOB CONTROL LANGUAGE CARDS
JOB CARD

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APPENDIX P

SAMPLE INPUT AND OUTPUT

AMRAW-B Sample Input

Sample input data for the base case for terminal storage phase, Case No. 48, are presented.

1. Table P-1. Data file AMB.[a]
2. Table P-2. Data file AM1E.[a]
   The full file for 50 times and 25 nuclides is 207 lines long; the beginning and end of the file is shown here.
3. Table P-3. Data file ECON48.
   This is the file with designation of form ECONxx for Case No. 48. The full file for 50 times, 25 nuclides, and 8 zones is 11,250 lines long; the beginning and end of the file is shown here, as obtained by processing AMRAW-A output through the auxiliary program, COMPRESS.
4. Tables P-4 and P-5. Sample of AMRAW-A output.
   These tables are a sample of AMRAW-A output prior to processing by COMPRESS to obtain the AMRAW-B input file illustrated in Table P-3.

   Table P-4. Average Annual Local Dose to Individual in Zone 1, from Ra-226, in Millirems/Year.

   Table P-5. Average Annual Nonspecific Dose to Population from Ra-226, in Man-rems/Year.

---

[a] The left hand line number column in these tables is computer-furnished for these listings and is not part of the data files.

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Table P-1. Data File AMB

```
     1234567890123456789012345678901234567890

3980 ECON48 - 50 PERIODS - NEW BODY COEFF.
3990 RATE                  0.0
4000 VOL              260000.0
4010 NT                     50
4020 MZ                      8
4030 NK                     25
4040 NIHT                    8
4050 TOTAL BODY (REMAIN.)   85
4060 GI TRACT               34
4070 GONAD(GENETIC)        200
4080 LIVER                   0
4090 LUNG                   44
4100 MARROW(LUKEMIA)        32
4110 BONE                    7
4120 THYROID                 0
4130 REPO        101       101
4140 EDDY      17200      6100
4150 REDB     213000     53600
4160 MIDO     784000    224000
4170 WTEX     217000     57900
4180 LEA      245000     74000
4190 CHAV     253000     67800
4200 REGB     155000     54900
4210 NG  11
4220 G01  2 19 25
4230 G02  5 11 13 15 20 21
4240 G03  6 10 12 14 17 22 24
4250 G04  3 16 18 23
4260 G05  1  1
4270 G06  2  2  3
4280 G07  2  4  5
4290 G08  1  6
4300 G09  1  7
4310 G10  1  8
4320 G11  1  9
```

Table P-2. Data File AM1E

```
1050   0.00E+00  5.00E+00  1.00E+01  1.50E+01  2.00E+01  2.50E+01  3.00E+01  4.00E+01
1060   5.00E+01  6.00E+01  7.00E+01  8.00E+01  9.00E+01  1.00E+02  2.00E+02  3.00E+02
1070   4.00E+02  5.00E+02  6.00E+02  7.00E+02  8.00E+02  9.00E+02  1.00E+03  2.00E+03
1080   3.00E+03  4.00E+03  5.00E+03  6.00E+03  7.00E+03  8.00E+03  9.00E+03  1.00E+04
1090   2.00E+04  3.00E+04  4.00E+04  5.00E+04  6.00E+04  7.00E+04  8.00E+04  9.00E+04
1100   1.00E+05  2.00E+05  3.00E+05  4.00E+05  5.00E+05  6.00E+05  7.00E+05  8.00E+05
1110   9.00E+05  1.00E+06
1170       C-14 1  0.0       6.14D+01  1.28D+03  4.07D+03  9.99D+03  2.17D+04  4.04D+04
1180       C-14 2  4.04D+04  4.04D+04  4.03D+04  4.02D+04  4.02D+04  4.01D+04  4.01D+04
1190       C-14 3  3.96D+04  3.91D+04  3.87D+04  3.82D+04  3.77D+04  3.73D+04  3.68D+04
1200       C-14 4  3.64D+04  3.59D+04  3.19D+04  2.82D+04  2.50D+04  2.21D+04  1.95D+04
1210       C-14 5  1.73D+04  1.54D+04  1.36D+04  1.21D+04  3.75D+03  1.07D+03  3.03D+02
1220       C-14 6  8.62D+01  2.49D+01  7.38D+00  2.24D+00  7.02D-01  2.26D-01  2.28D-06
1230       C-14 7  7.03D-12  1.50D-17  3.72D-23  0.0       0.0       0.0       0.0
1240       C-14 8  0.0
1250      SR-90 1  5.30D+05  3.89D+06  1.06D+07  2.24D+07  4.22D+07  7.11D+07  6.28D+07
1260      SR-90 2  4.91D+07  3.90D+07  3.09D+07  2.43D+07  1.91D+07  1.48D+07  1.15D+07
1270      SR-90 3  8.87D+05  7.72D+04  7.82D+03  7.85D+02  7.21D+01  6.10D+00  4.83D-01
1280      SR-90 4  3.65D-02  2.68D-03  1.62D-14  8.95D-25  0.0       0.0       0.0
1290      SR-90 5  0.0       0.0       0.0       0.0       0.0       0.0       0.0
1300      SR-90 6  0.0       0.0       0.0       0.0       0.0       0.0       0.0
1310      SR-90 7  0.0       0.0       0.0       0.0       0.0       0.0       0.0
1320      SR-90 8  0.0
1330       Y-90 1  1.38D+02  1.01D+03  2.75D+03  5.82D+03  1.10D+04  1.85D+04  1.63D+04
1340       Y-90 2  1.28D+04  1.02D+04  8.06D+03  6.34D+03  4.95D+03  3.86D+03  2.99D+03
1350       Y-90 3  2.30D+02  2.00D+01  2.03D+00  2.04D-01  1.87D-02  1.58D-03  1.25D-04
1360       Y-90 4  9.48D-06  6.96D-07  4.20D-18  0.0       0.0       0.0       0.0
1370       Y-90 5  0.0       0.0       0.0       0.0       0.0       0.0       0.0
1380       Y-90 6  0.0       0.0       0.0       0.0       0.0       0.0       0.0
1390       Y-90 7  0.0       0.0       0.0       0.0       0.0       0.0       0.0
1400       Y-90 8  0.0
1410      ZR-93 1  8.44D+05  6.38D+06  1.82D+07  4.00D+07  7.72D+07  1.33D+08  1.33D+08
1420      ZR-93 2  1.33D+08  1.33D+08  1.33D+08  1.33D+08  1.33D+08  1.33D+08  1.33D+08
1430      ZR-93 3  1.33D+08  1.33D+08  1.33D+08  1.33D+08  1.33D+08  1.33D+08  1.33D+08
1440      ZR-93 4  1.33D+08  1.33D+08  1.33D+08  1.33D+08  1.33D+08  1.33D+08  1.32D+08
1450      ZR-93 5  1.32D+08  1.32D+08  1.32D+08  1.32D+08  1.31D+08  1.31D+08  1.30D+08
1460      ZR-93 6  1.30D+08  1.29D+08  1.29D+08  1.28D+08  1.28D+08  1.27D+08  1.22D+08

                   5.95D+05  5.69D+05  5.43D+05  5.19D+05  4.95D+05  4.73D+05  4.52D+05
2870   AM-242M 3  2.90D+05  1.83D+05  1.14D+05  7.10D+04  4.44D+04  2.80D+04  1.78D+04
2880   AM-242M 4  1.14D+04  7.40D+03  9.66D+01  8.24D-01  6.08D-03  4.71D-05  4.14D-07
2890   AM-242M 5  4.22D-09  5.02D-11  6.92D-13  1.10D-14  0.0       0.0       0.0
2900   AM-242M 6  0.0       0.0       0.0       0.0       0.0       0.0       0.0
2910   AM-242M 7  0.0       0.0       0.0       0.0       0.0       0.0       0.0
2920   AM-242M 8  0.0
2930     AM-243 1  1.08D+05  1.17D+06  9.45D+06  2.55D+07  4.98D+07  7.25D+07  7.25D+07
2940     AM-243 2  7.24D+07  7.23D+07  7.23D+07  7.22D+07  7.21D+07  7.21D+07  7.20D+07
2950     AM-243 3  7.14D+07  7.07D+07  7.00D+07  6.94D+07  6.87D+07  6.81D+07  6.75D+07
2960     AM-243 4  6.69D+07  6.64D+07  6.10D+07  5.54D+07  5.01D+07  4.54D+07  4.13D+07
2970     AM-243 5  3.77D+07  3.45D+07  3.18D+07  2.94D+07  1.29D+07  4.80D+06  1.66D+06
2980     AM-243 6  5.92D+05  2.25D+05  9.11D+04  3.93D+04  1.79D+04  8.56D+03  4.87D+01
2990     AM-243 7  3.75D+00  1.08D+00  6.45D-01  5.98D-01  7.39D-01  1.11D+00  1.91D+00
3000     AM-243 8  3.64D+00
3010     CM-242 1  3.05D+00  3.09D+01  2.16D+02  5.61D+02  1.07D+03  1.58D+03  1.50D+03
3020     CM-242 2  1.43D+03  1.37D+03  1.31D+03  1.25D+03  1.19D+03  1.14D+03  1.09D+03
3030     CM-242 3  6.98D+02  4.40D+02  2.74D+02  1.71D+02  1.07D+02  6.73D+01  4.28D+01
3040     CM-242 4  2.75D+01  1.78D+01  2.33D-01  1.99D-03  1.47D-05  1.14D-07  1.00D-09
3050     CM-242 5  1.02D-11  1.21D-13  1.67D-15  2.66D-17  1.16D-32  0.0       0.0
3060     CM-242 6  0.0       0.0       0.0       0.0       0.0       0.0       0.0
3070     CM-242 7  0.0       0.0       0.0       0.0       0.0       0.0       0.0
3080     CM-242 8  0.0
3090     CM-244 1  2.66D+04  3.76D+05  3.92D+06  1.03D+07  1.91D+07  2.47D+07  2.04D+07
3100     CM-244 2  1.39D+07  9.73D+06  6.79D+06  4.69D+06  3.21D+06  2.18D+06  1.47D+06
3110     CM-244 3  2.75D+04  6.19D+02  1.76D+01  4.97D-01  1.22D-02  2.63D-04  5.14D-06
3120     CM-244 4  9.33D-08  1.62D-09  0.0       0.0       0.0       0.0       0.0
3130     CM-244 5  0.0       0.0       0.0       0.0       0.0       0.0       0.0
3140     CM-244 6  0.0       0.0       0.0       0.0       0.0       0.0       0.0
3150     CM-244 7  0.0       0.0       0.0       0.0       0.0       0.0       0.0
3160     CM-244 8  0.0
```

Table P-3. Data File ECON48

```
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
2.40E-12   3.03E-11   8.05E-13   0.0        3.37E-10   1.28E-11   1.28E-11   0.0
3.41E-12   4.29E-11   1.14E-12   0.0        4.77E-10   1.82E-11   1.82E-11   0.0
4.41E-12   5.55E-11   1.48E-12   0.0        6.17E-10   2.35E-11   2.35E-11   0.0
5.40E-12   6.80E-11   1.81E-12   0.0        7.56E-10   2.88E-11   2.88E-11   0.0
6.39E-12   8.05E-11   2.14E-12   0.0        8.95E-10   3.40E-11   3.40E-11   0.0
7.38E-12   9.29E-11   2.47E-12   0.0        1.03E-09   3.93E-11   3.93E-11   0.0
8.36E-12   1.05E-10   2.80E-12   0.0        1.17E-09   4.46E-11   4.46E-11   0.0
1.82E-11   2.29E-10   6.10E-12   0.0        2.55E-09   9.71E-11   9.71E-11   0.0
2.77E-11   3.49E-10   9.29E-12   0.0        3.89E-09   1.48E-10   1.48E-10   0.0
3.70E-11   4.66E-10   1.24E-11   0.0        5.15E-09   1.97E-10   1.97E-10   0.0
4.61E-11   5.80E-10   1.54E-11   0.0        6.46E-09   2.46E-10   2.46E-10   0.0
5.48E-11   6.90E-10   1.84E-11   0.0        7.68E-09   2.92E-10   2.92E-10   0.0
6.34E-11   7.98E-10   2.12E-11   0.0        8.88E-09   3.38E-10   3.38E-10   0.0
7.17E-11   9.03E-10   2.40E-11   0.0        1.00E-08   3.82E-10   3.82E-10   0.0
7.98E-11   1.00E-09   2.67E-11   0.0        1.12E-08   4.25E-10   4.25E-10   0.0
8.76E-11   1.10E-09   2.93E-11   0.0        1.23E-08   4.67E-10   4.67E-10   0.0
1.65E-10   2.08E-09   5.54E-11   0.0        2.32E-08   8.82E-10   8.82E-10   0.0
2.18E-10   2.75E-09   7.30E-11   0.0        3.06E-08   1.16E-09   1.16E-09   0.0
2.55E-10   3.21E-09   8.53E-11   0.0        3.57E-08   1.36E-09   1.36E-09   0.0
2.79E-10   3.51E-09   9.35E-11   0.0        3.91E-08   1.49E-09   1.49E-09   0.0
2.93E-10   3.69E-09   9.80E-11   0.0        4.10E-08   1.56E-09   1.56E-09   0.0
2.99E-10   3.76E-09   1.00E-10   0.0        4.19E-08   1.59E-09   1.59E-09   0.0
3.00E-10   3.78E-09   1.01E-10   0.0        4.20E-08   1.60E-09   1.60E-09   0.0
2.96E-10   3.73E-09   9.92E-11   0.0        4.15E-08   1.58E-09   1.58E-09   0.0
2.88E-10   3.63E-09   9.66E-11   0.0        4.04E-08   1.54E-09   1.54E-09   0.0
3.54E-10   4.46E-09   1.19E-10   0.0        4.96E-08   1.89E-09   1.89E-09   0.0
1.45E-10   1.83E-09   4.87E-11   0.0        2.04E-08   7.75E-10   7.75E-10   0.0
5.00E-11   6.30E-10   1.67E-11   0.0        7.01E-09   2.67E-10   2.67E-10   0.0
1.61E-11   2.03E-10   5.39E-12   0.0        2.26E-09   8.58E-11   8.58E-11   0.0
5.03E-12   6.34E-11   1.69E-12   0.0        7.05E-10   2.68E-11   2.68E-11   0.0
1.56E-12   1.97E-11   5.24E-13   0.0        2.15E-10   8.33E-12   8.33E-12   0.0
4.90E-13   6.17E-12   1.64E-13   0.0        6.86E-11   2.61E-12   2.61E-12   0.0
1.56E-13   1.96E-12   5.21E-14   0.0        2.18E-11   8.30E-13   8.30E-13   0.0
5.06E-14   6.37E-13   1.69E-14   0.0        7.08E-12   2.69E-13   2.69E-13   0.0
3.16E-14   3.98E-13   1.06E-14   0.0        4.42E-12   1.68E-13   1.68E-13   0.0
3.16E-19   3.97E-18   1.06E-19   0.0        4.42E-17   1.68E-18   1.68E-18   0.0
9.72E-25   1.22E-23   3.25E-25   0.0        1.36E-22   5.18E-24   5.18E-24   0.0
2.08E-31   2.62E-30   6.96E-32   0.0        2.91E-29   1.11E-30   1.11E-30   0.0
5.16E-38   6.50E-37   1.73E-38   0.0        7.23E-36   2.75E-37   2.75E-37   0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0

0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
2.15E-02   4.52E-03   1.75E-02   3.35E-01   0.0        7.27E-01   7.27E-01   0.0
1.49E-02   3.13E-03   1.21E-02   2.32E-01   0.0        5.03E-01   5.03E-01   0.0
1.04E-02   2.19E-03   8.48E-03   1.63E-01   0.0        3.53E-01   3.53E-01   0.0
7.29E-03   1.53E-03   5.91E-03   1.14E-01   0.0        2.46E-01   2.46E-01   0.0
5.03E-03   1.06E-03   4.08E-03   7.84E-02   0.0        1.70E-01   1.70E-01   0.0
3.45E-03   7.24E-04   2.80E-03   5.37E-02   0.0        1.16E-01   1.16E-01   0.0
2.34E-03   4.92E-04   1.90E-03   3.65E-02   0.0        7.91E-02   7.91E-02   0.0
9.58E-04   2.10E-04   8.10E-04   1.56E-02   0.0        3.37E-02   3.37E-02   0.0
1.94E-05   4.08E-06   1.58E-05   3.03E-04   0.0        6.56E-04   6.56E-04   0.0
4.55E-07   9.55E-08   3.69E-07   7.09E-06   0.0        1.54E-05   1.54E-05   0.0
1.34E-08   2.81E-09   1.08E-08   2.08E-07   0.0        4.51E-07   4.51E-07   0.0
3.88E-10   8.15E-11   3.15E-10   6.05E-09   0.0        1.31E-08   1.31E-08   0.0
9.79E-12   2.06E-12   7.94E-12   1.53E-10   0.0        3.31E-10   3.31E-10   0.0
2.17E-13   4.56E-14   1.76E-13   3.38E-12   0.0        7.32E-12   7.32E-12   0.0
4.36E-15   9.15E-16   3.54E-15   6.79E-14   0.0        1.47E-13   1.47E-13   0.0
8.12E-17   1.71E-17   6.59E-17   1.27E-15   0.0        2.74E-15   2.74E-15   0.0
1.78E-18   3.74E-19   1.45E-18   2.78E-17   0.0        6.01E-17   6.01E-17   0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
```

Table P-4. Sample of AMRAW-A Output

```
** AVERAGE ANNUAL LOCAL DOSE TO INDIVIDUAL. MANIL. IN MILLIREMS/YEAR

ZONE= 1... NUCLIDE=  RA-226  K= 12

     TIME   TOT BODY   GI TRACT   GONADS     LIVER      LUNGS      MARROW     BONE       THYROID
       0.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
       5.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
      10.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
      15.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
      20.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
      25.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
      30.   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
      40.   1.42E-13   6.24E-16   1.42E-13   5.72E-16   4.13E-13   1.68E-12   1.68E-12   7.25E-16
      50.   2.43E-13   1.42E-15   2.44E-13   1.37E-15   7.05E-13   2.87E-12   2.87E-12   1.75E-15
      60.   3.82E-13   2.53E-15   3.83E-13   2.49E-15   1.11E-12   4.51E-12   4.51E-12   3.17E-15
      70.   5.68E-13   4.04E-15   5.69E-13   4.02E-15   1.65E-12   6.69E-12   6.69E-12   5.12E-15
      80.   8.12E-13   6.04E-15   8.14E-13   6.05E-15   2.35E-12   9.56E-12   9.56E-12   7.71E-15
      90.   1.12E-12   8.63E-15   1.13E-12   8.67E-15   3.25E-12   1.32E-11   1.32E-11   1.11E-14
     100.   1.52E-12   1.19E-14   1.52E-12   1.20E-14   4.39E-12   1.78E-11   1.78E-11   1.53E-14
     200.   9.15E-12   7.89E-14   9.18E-12   8.03E-14   2.65E-11   1.08E-10   1.08E-10   1.03E-13
     300.   4.10E-11   3.63E-13   4.12E-11   3.70E-13   1.19E-10   4.82E-10   4.82E-10   4.73E-13
     400.   1.20E-10   1.07E-12   1.20E-10   1.10E-12   3.46E-10   1.41E-09   1.41E-09   1.40E-12
     500.   2.69E-10   2.43E-12   2.70E-10   2.48E-12   7.78E-10   3.16E-09   3.16E-09   3.17E-12
     600.   5.14E-10   4.65E-12   5.15E-10   4.76E-12   1.49E-09   6.04E-09   6.04E-09   6.08E-12
     700.   8.76E-10   7.97E-12   8.79E-10   8.15E-12   2.53E-09   1.03E-08   1.03E-08   1.04E-11
     800.   1.38E-09   1.25E-11   1.38E-09   1.28E-11   3.98E-09   1.62E-08   1.62E-08   1.64E-11
     900.   2.03E-09   1.86E-11   2.04E-09   1.90E-11   5.88E-09   2.39E-08   2.39E-08   2.43E-11
    1000.   2.87E-09   2.63E-11   2.88E-09   2.69E-11   8.31E-09   3.38E-08   3.38E-08   3.43E-11
    2000.   1.61E-08   1.48E-10   1.62E-08   1.52E-10   4.66E-08   1.89E-07   1.89E-07   1.94E-10
    3000.   5.88E-08   5.42E-10   5.90E-08   5.55E-10   1.70E-07   6.91E-07   6.91E-07   7.09E-10
    4000.   1.37E-07   1.26E-09   1.37E-07   1.29E-09   3.95E-07   1.60E-06   1.60E-06   1.65E-09
    5000.   2.52E-07   2.32E-09   2.52E-07   2.38E-09   7.27E-07   2.96E-06   2.96E-06   3.04E-09
    6000.   4.04E-07   3.74E-09   4.06E-07   3.83E-09   1.17E-06   4.75E-06   4.75E-06   4.89E-09
    7000.   5.94E-07   5.49E-09   5.96E-07   5.62E-09   1.72E-06   6.98E-06   6.98E-06   7.18E-09
    8000.   8.19E-07   7.57E-09   8.21E-07   7.75E-09   2.37E-06   9.62E-06   9.62E-06   9.90E-09
    9000.   1.08E-06   9.98E-09   1.08E-06   1.02E-08   3.12E-06   1.27E-05   1.27E-05   1.31E-08
   10000.   1.38E-06   1.27E-08   1.38E-06   1.30E-08   3.98E-06   1.62E-05   1.62E-05   1.67E-08
   20000.   4.85E-06   4.49E-08   4.87E-06   4.60E-08   1.40E-05   5.70E-05   5.70E-05   5.87E-08
   30000.   1.15E-05   1.06E-07   1.15E-05   1.09E-07   3.32E-05   1.35E-04   1.35E-04   1.39E-07
   40000.   1.91E-05   1.77E-07   1.92E-05   1.81E-07   5.52E-05   2.24E-04   2.24E-04   2.31E-07
   50000.   2.66E-05   2.46E-07   2.67E-05   2.52E-07   7.69E-05   3.13E-04   3.13E-04   3.22E-07
   60000.   3.36E-05   3.11E-07   3.37E-05   3.19E-07   9.72E-05   3.95E-04   3.95E-04   4.07E-07
   70000.   4.01E-05   3.71E-07   4.03E-05   3.80E-07   1.16E-04   4.71E-04   4.71E-04   4.86E-07
   80000.   4.59E-05   4.25E-07   4.60E-05   4.35E-07   1.33E-04   5.39E-04   5.39E-04   5.56E-07
   90000.   5.09E-05   4.71E-07   5.11E-05   4.83E-07   1.47E-04   5.98E-04   5.98E-04   6.17E-07
  100000.   5.53E-05   5.12E-07   5.55E-05   5.24E-07   1.60E-04   6.50E-04   6.50E-04   6.70E-07
  200000.   1.59E-04   1.47E-06   1.59E-04   1.50E-06   4.58E-04   1.86E-03   1.86E-03   1.92E-06
  300000.   1.62E-04   1.50E-06   1.62E-04   1.53E-06   4.68E-04   1.90E-03   1.90E-03   1.96E-06
  400000.   1.40E-04   1.29E-06   1.40E-04   1.33E-06   4.04E-04   1.64E-03   1.64E-03   1.69E-06
  500000.   1.13E-04   1.04E-06   1.13E-04   1.07E-06   3.26E-04   1.32E-03   1.32E-03   1.36E-06
  600000.   8.80E-05   8.15E-07   8.83E-05   8.34E-07   2.54E-04   1.03E-03   1.03E-03   1.07E-06
  760000.   6.80E-05   6.30E-07   6.82E-05   6.45E-07   1.97E-04   7.99E-04   7.99E-04   8.24E-07
  800000.   5.25E-05   4.86E-07   5.27E-05   4.98E-07   1.52E-04   6.17E-04   6.17E-04   6.36E-07
  900000.   4.05E-05   3.75E-07   4.06E-05   3.84E-07   1.17E-04   4.75E-04   4.75E-04   4.90E-07
 1000000.   3.13E-05   2.89E-07   3.14E-05   2.97E-07   9.04E-05   3.67E-04   3.67E-04   3.79E-07
```

Table P-5. Sample of AMRAW-A Output

```
** AVERAGE ANNUAL NONSPECIFIC DOSE TO POPULATION, MANIN, IN MANREMS/YEAR

NONSPECIFIC ... NUCLIDE=  RA-226  K= 12

     TIME    TOT BODY  GI TRACT   GONADS     LIVER      LUNGS     MARROW     BONE      THYROID
       0.    0.0       0.0        0.0        0.0        0.0        0.0        0.0        0.0
       5.    0.0       0.0        0.0        0.0        0.0        0.0        0.0        0.0
      10.    0.0       0.0        0.0        0.0        0.0        0.0        0.0        0.0
      15.    0.0       0.0        0.0        0.0        0.0        0.0        0.0        0.0
      20.    0.0       0.0        0.0        0.0        0.0        0.0        0.0        0.0
      25.    0.0       0.0        0.0        0.0        0.0        0.0        0.0        0.0
      30.    0.0       0.0        0.0        0.0        0.0        0.0        0.0        0.0
      40.    6.48E-10  1.35E-12   6.48E-10   1.20E-13   0.0        7.71E-09   7.71E-09   0.0
      50.    1.00E-09  2.08E-12   1.00E-09   1.85E-13   0.0        1.19E-08   1.19E-08   0.0
      60.    1.47E-09  3.07E-12   1.47E-09   2.73E-13   0.0        1.75E-08   1.75E-08   0.0
      70.    2.09E-09  4.35E-12   2.09E-09   3.87E-13   0.0        2.49E-08   2.49E-08   0.0
      80.    2.89E-09  6.01E-12   2.89E-09   5.34E-13   0.0        3.43E-08   3.43E-08   0.0
      90.    3.89E-09  8.09E-12   3.89E-09   7.19E-13   0.0        4.63E-08   4.63E-08   0.0
     100.    5.14E-09  1.07E-11   5.14E-09   9.51E-13   0.0        6.12E-08   6.12E-08   0.0
     200.    3.03E-08  6.30E-11   3.03E-08   5.60E-12   0.0        3.60E-07   3.60E-07   0.0
     300.    1.32E-07  2.75E-10   1.32E-07   2.44E-11   0.0        1.57E-06   1.57E-06   0.0
     400.    3.77E-07  7.85E-10   3.77E-07   6.98E-11   0.0        4.49E-06   4.49E-06   0.0
     500.    8.35E-07  1.74E-09   8.35E-07   1.54E-10   0.0        9.93E-06   9.93E-06   0.0
     600.    1.57E-06  3.27E-09   1.57E-06   2.91E-10   0.0        1.87E-05   1.87E-05   0.0
     700.    2.66E-06  5.54E-09   2.66E-06   4.92E-10   0.0        3.17E-05   3.17E-05   0.0
     800.    4.15E-06  8.63E-09   4.15E-06   7.67E-10   0.0        4.94E-05   4.94E-05   0.0
     900.    6.10E-06  1.27E-08   6.10E-06   1.13E-09   0.0        7.26E-05   7.26E-05   0.0
    1000.    8.58E-06  1.78E-08   8.58E-06   1.59E-09   0.0        1.02E-04   1.02E-04   0.0
    2000.    5.02E-05  1.04E-07   5.02E-05   9.28E-09   0.0        5.97E-04   5.97E-04   0.0
    3000.    1.82E-04  3.79E-07   1.82E-04   3.37E-08   0.0        2.17E-03   2.17E-03   0.0
    4000.    4.18E-04  8.69E-07   4.18E-04   7.73E-08   0.0        4.97E-03   4.97E-03   0.0
    5000.    7.63E-04  1.59E-06   7.63E-04   1.41E-07   0.0        9.08E-03   9.08E-03   0.0
    6000.    1.22E-03  2.53E-06   1.22E-03   2.25E-07   0.0        1.45E-02   1.45E-02   0.0
    7000.    1.78E-03  3.69E-06   1.78E-03   3.28E-07   0.0        2.11E-02   2.11E-02   0.0
    8000.    2.44E-03  5.07E-06   2.44E-03   4.51E-07   0.0        2.90E-02   2.90E-02   0.0
    9000.    3.20E-03  6.66E-06   3.20E-03   5.92E-07   0.0        3.81E-02   3.81E-02   0.0
   10000.    4.07E-03  8.47E-06   4.07E-03   7.53E-07   0.0        4.84E-02   4.84E-02   0.0
   20000.    1.51E-02  3.14E-05   1.51E-02   2.79E-06   0.0        1.80E-01   1.80E-01   0.0
   30000.    3.57E-02  7.43E-05   3.57E-02   6.60E-06   0.0        4.25E-01   4.25E-01   0.0
   40000.    5.89E-02  1.23E-04   5.89E-02   1.09E-05   0.0        7.01E-01   7.01E-01   0.0
   50000.    8.16E-02  1.70E-04   8.16E-02   1.51E-05   0.0        9.71E-01   9.71E-01   0.0
   60000.    1.03E-01  2.14E-04   1.03E-01   1.90E-05   0.0        1.22E 00   1.22E 00   0.0
   70000.    1.22E-01  2.54E-04   1.22E-01   2.26E-05   0.0        1.45E 00   1.45E 00   0.0
   80000.    1.39E-01  2.89E-04   1.39E-01   2.57E-05   0.0        1.65E 00   1.65E 00   0.0
   90000.    1.54E-01  3.21E-04   1.54E-01   2.85E-05   0.0        1.83E 00   1.83E 00   0.0
  100000.    1.67E-01  3.48E-04   1.67E-01   3.09E-05   0.0        1.99E 00   1.99E 00   0.0
  200000.    5.14E-01  1.07E-03   5.14E-01   9.50E-05   0.0        6.12E 00   6.12E 00   0.0
  300000.    5.27E-01  1.10E-03   5.27E-01   9.75E-05   0.0        6.27E 00   6.27E 00   0.0
  400000.    4.55E-01  9.47E-04   4.55E-01   8.42E-05   0.0        5.42E 00   5.42E 00   0.0
  500000.    3.67E-01  7.64E-04   3.67E-01   6.79E-05   0.0        4.37E 00   4.37E 00   0.0
  600000.    2.87E-01  5.96E-04   2.87E-01   5.30E-05   0.0        3.41E 00   3.41E 00   0.0
  700000.    2.22E-01  4.61E-04   2.22E-01   4.10E-05   0.0        2.64E 00   2.64E 00   0.0
  800000.    1.71E-01  3.56E-04   1.71E-01   3.16E-05   0.0        2.03E 00   2.03E 00   0.0
  900000.    1.32E-01  2.74E-04   1.32E-01   2.44E-05   0.0        1.57E 00   1.57E 00   0.0
 1000000.    1.02E-01  2.12E-04   1.02E-01   1.88E-05   0.0        1.21E 00   1.21E 00   0.0
```

AMRAW-B Sample Output

This section of Appendix P contains output for the full run base case for terminal storage phase, Case No. 48, and is based on the total of cancers and genetic effects.

1. Output Summary of Selected Input: Table P-6.

2. Annual Damage Rates, by Zone, Nonspecific and Total

   a. Table P-7 (Output Table 1-1). Zonal and Total Damages for High Population Projection ($/y).

   b. Table P-8 (Output Table 1-2). Zonal and Total Damages for Low Population Projection ($/y).

3. Annual Damage Rates, by Nuclide, Total All Zones, and Nonspecific

   Table P-9. (Output Tables 2-9 (50 y), 2-14 (100 y)). The full output of this type is a table for all times calculated after 30 y.

4. Discounted Present Values of Damage Costs by Nuclide, and Total, Integrated Over 10^6 Years

   Table P-10 (Output Table F-10). Discounted Present Values ($), Discount Rate = 0.00%.

5. Number of Deaths per Time Interval

   a. Table P-11 (Output Table 4-1). High Population Scenario: Number of Deaths per Time Interval (#/Δy).

   b. Table P-12 (Output Table 4-2). Low Population Scenario: Number of Deaths per Time Interval (#/Δy).

6. Total Undiscounted Damages per Time Interval, by Zone

   a. Table P-13 (Output Table 5-1). Total Undiscounted Damages for Each Zone for Each Time Interval - High Population ($/Δy).

   b. Table P-14 (Output Table 5-2). Total Undiscounted Damages for Each Zone for Each Time Interval - Low Population ($/Δy).

Appendix P

Table P-6. Output Summary of Selected Input

```
ECON48 - 50 PERIODS - NEW BODY COEFF.

DISCOUNT RATE = 0.00 %
COST OF INCREASED LEVEL OF RISK OF DEATH = $ 260000.

                               COST OF EXCESS RISK OF DEATH
  SITE OR TYPE           DEATH /MIL. MAN-REM    $/MAN-REM

TOTAL BODY (REMAIN.)                85.0              22.1
GI TRACT                            34.0               8.8
GONAD(GENETIC)                     200.0              52.0
LIVER                                0.0               0.0
LUNG                                44.0              11.4
MARROW(LUKEMIA)                     32.0               8.3
BONE                                 7.0               1.8
THYROID                              0.0               0.0


  POPULATION PROJECTIONS
 ZONE        HIGH        LOW

1 REPO        101.       101.
2 EDDY      17200.      6100.
3 REDB     213000.     53600.
4 MIDO     784000.    224000.
5 WTEX     217000.     57900.
6 LEA      245000.     74000.
7 CHAV     253000.     67800.
8 REGB     155000.     54900.
```

Appendix P

Table P-7. AMRAW-B Output Table 1-1

```
                          TABLE 1 - 1 : ZONAL AND TOTAL DAMAGES FOR HIGH POP. PROJECTION ($/YR)
   TIME  REPO       EDDY       REDB       MIDO       WTZX       LTA        CHAV       RI39       TOT.ZONE   NON-SPEC   TTOTAL
     0.  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     5.  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
    10.  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
    15.  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
    20.  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
    25.  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
    30.  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
    40.  1.61E-01   2.42E 00   1.58E 00   5.06E-01   2.34E-01   1.93E 00   2.28E 00   3.97E 00   1.31E 01   6.00E 01   7.30E 01
    50.  1.70E-01   3.70E 00   2.32E 00   6.62E-01   3.03E-01   2.47E 00   3.41E 00   4.82E 00   1.79E 01   5.02E 01   6.80E 01
    60.  1.69E-01   4.33E 00   2.65E 00   7.25E-01   3.31E-01   2.68E 00   3.91E 00   4.76E 00   1.96E 01   4.22E 01   6.17E 01
    70.  1.62E-01   4.52E 00   2.71E 00   7.34E-01   3.34E-01   2.70E 00   4.00E 00   4.37E 00   1.95E 01   3.51E 01   5.46E 01
    80.  1.52E-01   4.43E 00   2.60E 00   7.15E-01   3.25E-01   2.63E 00   3.83E 00   3.91E 00   1.86E 01   2.91E 01   4.77E 01
    90.  1.43E-01   4.18E 00   2.40E 00   6.86E-01   3.12E-01   2.51E 00   3.53E 00   3.47E 00   1.72E 01   2.40E 01   4.12E 01
   100.  1.35E-01   3.84E 00   2.17E 00   6.59E-01   2.99E-01   2.42E 00   3.17E 00   3.10E 00   1.58E 01   1.96E 01   3.54E 01
   200.  1.98E-01   4.89E 00   2.43E 00   1.04E 00   4.71E-01   3.78E 00   3.41E 00   6.11E 00   2.23E 01   1.45E 01   3.68E 01
   300.  1.74E-01   1.95E 00   1.28E 00   9.46E-01   4.28E-01   3.43E 00   1.61E 00   3.57E 00   1.35E 01   2.40E 00   1.59E 01
   400.  1.89E-01   1.84E 00   1.36E 00   1.04E 00   4.71E-01   3.78E 00   1.70E 00   3.81E 00   1.42E 01   1.11E 00   1.53E 01
   500.  2.04E-01   2.02E 00   1.51E 00   1.14E 00   5.14E-01   4.12E 00   1.89E 00   4.07E 00   1.55E 01   9.03E-01   1.64E 01
   600.  2.19E-01   2.18E 00   1.63E 00   1.22E 00   5.52E-01   4.43E 00   2.05E 00   4.29E 00   1.66E 01   8.25E-01   1.74E 01
   700.  2.31E-01   2.31E 00   1.73E 00   1.27E 00   5.84E-01   4.68E 00   2.16E 00   4.46E 00   1.74E 01   7.64E-01   1.82E 01
   800.  2.40E-01   2.38E 00   1.79E 00   1.34E 00   6.07E-01   4.87E 00   2.23E 00   4.59E 00   1.81E 01   7.06E-01   1.88E 01
   900.  2.46E-01   2.42E 00   1.82E 00   1.38E 00   6.25E-01   5.01E 00   2.27E 00   4.66E 00   1.84E 01   6.54E-01   1.91E 01
  1000.  2.51E-01   2.44E 00   1.84E 00   1.41E 00   6.38E-01   5.12E 00   2.29E 00   4.71E 00   1.87E 01   6.07E-01   1.93E 01
  2000.  3.95E-01   3.67E 00   2.80E 00   2.24E 00   1.01E 00   8.09E 00   3.44E 00   8.25E 00   2.99E 01   5.86E-01   3.05E 01
  3000.  4.22E-01   3.60E 00   2.80E 00   2.40E 00   1.08E 00   8.66E 00   3.37E 00   8.53E 00   3.08E 01   4.89E-01   3.13E 01
  4000.  4.91E-01   4.05E 00   3.10E 00   2.78E 00   1.26E 00   1.01E 01   3.80E 00   9.68E 00   3.53E 01   5.39E-01   3.59E 01
  5000.  5.54E-01   4.51E 00   3.55E 00   3.15E 00   1.42E 00   1.14E 01   4.23E 00   1.07E 01   3.95E 01   6.23E-01   4.02E 01
  6000.  6.07E-01   4.86E 00   3.86E 00   3.45E 00   1.56E 00   1.25E 01   4.57E 00   1.18E 01   4.30E 01   7.65E-01   4.37E 01
  7000.  6.50E-01   5.17E 00   4.10E 00   3.69E 00   1.67E 00   1.34E 01   4.85E 00   1.23E 01   4.58E 01   1.25E 00   4.70E 01
  8000.  6.85E-01   5.40E 00   4.29E 00   3.89E 00   1.76E 00   1.41E 01   5.05E 00   1.28E 01   4.80E 01   3.78E 00   5.18E 01
  9000.  7.13E-01   5.62E 00   4.43E 00   4.05E 00   1.83E 00   1.47E 01   5.19E 00   1.33E 01   4.98E 01   1.18E 01   6.16E 01
 10000.  7.36E-01   5.84E 00   4.55E 00   4.18E 00   1.89E 00   1.52E 01   5.31E 00   1.36E 01   5.13E 01   2.44E 01   7.57E 01
 20000.  1.11E 00   8.41E 00   6.62E 00   6.27E 00   2.83E 00   2.27E 01   7.67E 00   2.22E 01   7.78E 01   3.61E 01   1.14E 02
 30000.  8.54E-01   6.68E 00   4.71E 00   4.84E 00   2.19E 00   1.75E 01   5.29E 00   1.69E 01   5.90E 01   1.54E 02   2.13E 02
 40000.  6.54E-01   5.44E 00   3.32E 00   3.71E 00   1.67E 00   1.34E 01   3.58E 00   1.85E 01   5.03E 01   3.03E 02   3.54E 02
 50000.  5.34E-01   5.02E 00   2.63E 00   3.03E 00   1.37E 00   1.10E 01   2.80E 00   2.02E 01   4.66E 01   4.13E 02   4.60E 02
 60000.  4.50E-01   4.98E 00   2.29E 00   2.55E 00   1.15E 00   9.25E 00   2.47E 00   2.01E 01   4.32E 01   4.74E 02   5.18E 02
 70000.  3.78E-01   5.04E 00   2.08E 00   2.15E 00   9.71E-01   7.79E 00   2.33E 00   1.91E 01   3.99E 01   5.10E 02   5.50E 02
 80000.  3.18E-01   5.10E 00   1.94E 00   1.80E 00   8.14E-01   6.53E 00   2.26E 00   1.80E 01   3.67E 01   5.30E 02   5.67E 02
 90000.  2.66E-01   5.14E 00   1.83E 00   1.51E 00   6.84E-01   5.48E 00   2.22E 00   1.69E 01   3.40E 01   5.41E 02   5.75E 02
100000.  2.27E-01   5.18E 00   1.76E 00   1.29E 00   5.83E-01   4.67E 00   2.21E 00   1.59E 01   3.19E 01   5.47E 02   5.78E 02
200000.  4.47E-01   6.84E 00   4.32E 00   2.54E 00   1.15E 00   9.20E 00   5.73E 00   1.50E 01   4.52E 01   2.38E 02   2.83E 02
300000.  3.80E-01   1.23E 01   4.18E 00   2.16E 00   9.78E-01   7.82E 00   5.70E 00   4.33E 01   7.68E 01   1.32E 03   1.39E 03
400000.  4.14E-01   1.05E 01   4.01E 00   2.36E 00   1.06E 00   8.53E 00   5.34E 00   3.63E 01   6.86E 01   1.04E 03   1.11E 03
500000.  4.30E-01   8.55E 00   3.69E 00   2.45E 00   1.10E 00   8.87E 00   4.77E 00   2.88E 01   5.86E 01   7.57E 02   8.16E 02
600000.  4.34E-01   6.93E 00   3.35E 00   2.46E 00   1.11E 00   8.92E 00   4.21E 00   2.31E 01   5.05E 01   5.43E 02   5.93E 02
700000.  4.29E-01   5.72E 00   3.03E 00   2.44E 00   1.10E 00   8.84E 00   3.72E 00   1.89E 01   4.42E 01   3.92E 02   4.37E 02
800000.  4.20E-01   1.06E 01   2.76E 00   2.39E 00   1.08E 00   8.63E 00   3.32E 00   1.59E 01   4.50E 01   2.87E 02   3.32E 02
900000.  4.07E-01   3.94E 02   2.53E 00   2.31E 00   1.05E 00   8.38E 00   2.97E 00   1.35E 01   4.25E 02   2.39E 02   6.64E 02
1000000. 3.92E-01   5.95E 03   2.33E 00   2.23E 00   1.01E 00   8.09E 00   2.70E 00   1.18E 01   5.98E 03   5.66E 02   6.55E 03
```

Appendix P. Table P-8. AMRAW-B Output Table 1-2

```
                          TABLE 1 - 2 : ZONAL AND TOTAL DAMAGES FOR  LOW POP. PROJECTION ($/YR)
    TIME  REPO         EDDY         REDB         MIDO         WTEX         LEA          CHAV         REGS         TOT.ZONE     NON-SPEC     TTOTAL
      0.  0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
      5.  0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
     10.  0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
     15.  0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
     20.  0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
     25.  0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
     30.  0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
     40.  1.61E-01     8.59E-01     3.97E-01     1.44E-01     6.25E-02     5.84E-01     6.10E-01     1.41E 00     4.23E 00     6.00E 01     6.42E 01
     50.  1.70E-01     1.31E 00     5.84E-01     1.89E-01     8.09E-02     7.47E-01     9.14E-01     1.71E 00     5.71E 00     5.02E 01     5.59E 01
     60.  1.69E-01     1.54E 00     6.68E-01     2.07E-01     8.82E-02     8.11E-01     1.05E 00     1.69E 00     6.21E 00     4.22E 01     4.84E 01
     70.  1.62E-01     1.60E 00     6.81E-01     2.10E-01     8.51E-02     8.16E-01     1.07E 00     1.55E 00     6.18E 00     3.51E 01     4.13E 01
     80.  1.52E-01     1.57E 00     6.54E-01     2.04E-01     8.66E-02     7.93E-01     1.03E 00     1.38E 00     5.87E 00     2.91E 01     3.50E 01
     90.  1.43E-01     1.48E 00     6.04E-01     1.96E-01     8.32E-02     7.60E-01     9.45E-01     1.23E 00     5.44E 00     2.40E 01     2.94E 01
    100.  1.35E-01     1.36E 00     5.46E-01     1.83E-01     7.98E-02     7.30E-01     8.50E-01     1.10E 00     4.99E 00     1.96E 01     2.46E 01
    200.  1.98E-01     1.74E 00     6.11E-01     2.57E-01     1.26E-01     1.14E 00     9.13E-01     2.16E 00     7.19E 00     1.45E 01     2.17E 01
    300.  1.74E-01     6.91E-01     3.22E-01     2.70E-01     1.14E-01     1.04E 00     4.31E-01     1.30E 00     4.34E 00     2.40E 00     6.74E 00
    400.  1.89E-01     6.53E-01     3.43E-01     2.98E-01     1.26E-01     1.14E 00     4.55E-01     1.35E 00     4.56E 00     1.11E 00     5.66E 00
    500.  2.04E-01     7.16E-01     3.80E-01     3.25E-01     1.37E-01     1.25E 00     5.06E-01     1.44E 00     4.96E 00     9.03E-01     5.86E 00
    600.  2.19E-01     7.75E-01     4.11E-01     3.49E-01     1.47E-01     1.34E 00     5.49E-01     1.52E 00     5.31E 00     8.25E-01     6.13E 00
    700.  2.31E-01     8.10E-01     4.34E-01     3.69E-01     1.56E-01     1.41E 00     5.80E-01     1.58E 00     5.58E 00     7.64E-01     6.35E 00
    800.  2.40E-01     8.44E-01     4.50E-01     3.84E-01     1.62E-01     1.47E 00     5.99E-01     1.62E 00     5.77E 00     7.06E-01     6.48E 00
    900.  2.46E-01     8.58E-01     4.58E-01     3.95E-01     1.67E-01     1.51E 00     6.09E-01     1.65E 00     5.90E 00     6.54E-01     6.55E 00
   1000.  2.51E-01     8.64E-01     4.63E-01     4.04E-01     1.70E-01     1.55E 00     6.13E-01     1.67E 00     5.98E 00     6.07E-01     6.59E 00
   2000.  3.95E-01     1.30E 00     7.05E-01     6.39E-01     2.70E-01     2.44E 00     9.23E-01     2.92E 00     9.60E 00     5.86E-01     1.02E 01
   3000.  4.22E-01     1.28E 00     7.05E-01     6.84E-01     2.88E-01     2.61E 00     9.02E-01     3.02E 00     9.91E 00     4.89E-01     1.04E 01
   4000.  4.91E-01     1.44E 00     8.01E-01     7.94E-01     3.36E-01     3.04E 00     1.02E 00     3.43E 00     1.13E 01     5.39E-01     1.19E 01
   5000.  5.54E-01     1.60E 00     8.94E-01     9.00E-01     3.79E-01     3.44E 00     1.13E 00     3.80E 00     1.27E 01     6.23E-01     1.33E 01
   6000.  6.07E-01     1.72E 00     9.70E-01     9.85E-01     4.15E-01     3.77E 00     1.23E 00     4.10E 00     1.38E 01     7.65E-01     1.46E 01
   7000.  6.50E-01     1.83E 00     1.03E 00     1.05E 00     4.45E-01     4.04E 00     1.30E 00     4.34E 00     1.47E 01     1.25E 00     1.59E 01
   8000.  6.85E-01     1.92E 00     1.08E 00     1.11E 00     4.69E-01     4.25E 00     1.35E 00     4.54E 00     1.54E 01     3.78E 00     1.92E 01
   9000.  7.13E-01     1.99E 00     1.11E 00     1.16E 00     4.88E-01     4.43E 00     1.39E 00     4.69E 00     1.60E 01     1.18E 01     2.78E 01
  10000.  7.36E-01     2.07E 00     1.14E 00     1.20E 00     5.04E-01     4.58E 00     1.42E 00     4.81E 00     1.65E 01     2.44E 01     4.09E 01
  20000.  1.11E 00     2.98E 00     1.67E 00     1.79E 00     7.54E-01     6.85E 00     2.06E 00     7.98E 00     2.51E 01     3.61E 01     6.12E 01
  30000.  8.54E-01     2.37E 00     1.19E 00     1.38E 00     5.83E-01     5.29E 00     1.42E 00     6.00E 00     1.91E 01     1.54E 02     1.73E 02
  40000.  6.54E-01     1.93E 00     8.35E-01     1.06E 00     4.46E-01     4.05E 00     9.59E-01     6.54E 00     1.65E 01     3.03E 02     3.20E 02
  50000.  5.34E-01     1.78E 00     6.62E-01     8.66E-01     3.65E-01     3.32E 00     7.49E-01     7.16E 00     1.54E 01     4.13E 02     4.28E 02
  60000.  4.50E-01     1.77E 00     5.75E-01     7.30E-01     3.08E-01     2.79E 00     6.63E-01     7.11E 00     1.44E 01     4.74E 02     4.89E 02
  70000.  3.78E-01     1.79E 00     5.24E-01     6.14E-01     2.59E-01     2.35E 00     6.25E-01     6.78E 00     1.33E 01     5.10E 02     5.23E 02
  80000.  3.18E-01     1.81E 00     4.87E-01     5.15E-01     2.17E-01     1.97E 00     6.05E-01     6.37E 00     1.23E 01     5.30E 02     5.43E 02
  90000.  2.66E-01     1.82E 00     4.60E-01     4.33E-01     1.83E-01     1.65E 00     5.95E-01     5.97E 00     1.14E 01     5.41E 02     5.52E 02
 100000.  2.27E-01     1.84E 00     4.42E-01     3.69E-01     1.55E-01     1.41E 00     5.93E-01     5.65E 00     1.07E 01     5.47E 02     5.57E 02
 200000.  4.47E-01     2.43E 00     1.09E 00     7.27E-01     3.06E-01     2.78E 00     1.54E 00     5.31E 00     1.46E 01     2.38E 02     2.53E 02
 300000.  3.80E-01     4.35E 00     1.05E 00     6.18E-01     2.61E-01     2.36E 00     1.53E 00     1.53E 01     2.59E 01     1.32E 03     1.34E 03
 400000.  4.14E-01     3.74E 00     1.01E 00     6.74E-01     2.84E-01     2.58E 00     1.43E 00     1.29E 01     2.30E 01     1.04E 03     1.07E 03
 500000.  4.30E-01     3.03E 00     9.29E-01     6.99E-01     2.95E-01     2.68E 00     1.28E 00     1.02E 01     1.95E 01     7.57E 02     7.77E 02
 600000.  4.34E-01     2.46E 00     8.42E-01     7.03E-01     2.97E-01     2.69E 00     1.13E 00     8.19E 00     1.67E 01     5.43E 02     5.60E 02
 700000.  4.29E-01     2.03E 00     7.64E-01     6.98E-01     2.94E-01     2.67E 00     9.98E-01     6.71E 00     1.46E 01     3.92E 02     4.07E 02
 800000.  4.20E-01     3.74E 00     6.96E-01     6.83E-01     2.88E-01     2.61E 00     8.90E-01     5.62E 00     1.49E 01     2.87E 02     3.02E 02
 900000.  4.07E-01     1.40E 02     6.37E-01     6.61E-01     2.79E-01     2.53E 00     7.97E-01     4.79E 03     1.50E 02     2.38E 02     3.88E 02
1000000.  3.92E-01     2.11E 03     5.87E-01     6.33E-01     2.69E-01     2.44E 00     7.23E-01     4.17E 00     2.12E 03     5.66E 02     2.69E 03
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Table P-9. Output Tables 2-9 and 2-14: AMRAW-B
Annual Damage Rates by Nuclide

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TABLE 2 -  9 : TIME PERIOD=        80.

NUCLIDE      HIGH POP     LOW POP      NON-SPEC     TOT-HIGH     TOT-LOW
   C-14      3.88E-07     1.22E-07     3.46E-06     3.85E-06     3.58E-06
  SR-90      9.09E 00     2.86E 00     3.61E 01     4.52E 01     3.89E 01
   Y-90      7.76E-02     2.43E-02     9.02E-02     1.68E-01     1.14E-01
  ZR-93      1.59E-07     5.06E-08     1.38E-06     1.53E-06     1.43E-06
 NB-93M      2.13E-07     6.74E-08     9.28E-06     9.49E-06     9.35E-06
  TC-99      3.92E-06     1.24E-06     2.30E-04     2.34E-04     2.31E-04
  I-129      6.19E-10     2.00E-10     1.17E-09     1.79E-09     1.37E-09
 CS-135      7.71E-07     2.41E-07     8.55E-06     9.32E-06     8.79E-06
 CS-137      6.92E-01     2.18E-01     6.64E 00     7.33E 00     6.86E 00
 PB-210      6.32E-10     2.00E-10     2.04E-09     2.67E-09     2.24E-09
 RA-225      3.70E-08     1.16E-08     3.76E-07     4.13E-07     3.88E-07
 RA-226      1.13E-08     3.54E-09     1.95E-07     2.06E-07     1.98E-07
 TH-229      9.73E-07     3.20E-07     1.80E-07     1.15E-06     5.00E-07
 TH-230      9.50E-08     3.13E-08     9.85E-09     1.05E-07     4.11E-08
 NP-237      6.89E-04     2.24E-04     8.05E-04     1.49E-03     1.03E-03
 NP-239      3.26E-03     1.06E-03     1.88E-05     3.28E-03     1.08E-03
 PU-238      6.59E-01     2.17E-01     3.43E-02     6.93E-01     2.52E-01
 PU-239      3.76E-03     1.24E-03     2.05E-04     3.97E-03     1.45E-03
 PU-240      5.92E-02     1.95E-02     3.23E-03     6.24E-02     2.28E-02
 PU-241      4.59E-03     1.51E-03     3.35E-04     4.92E-03     1.85E-03
 AM-241      8.27E-01     2.68E-01     9.58E-01     1.78E 00     1.23E 00
AM-242M      6.34E-02     2.05E-02     8.09E-02     1.44E-01     1.01E-01
 AM-243      1.75E-01     5.67E-02     2.04E-01     3.79E-01     2.61E-01
 CM-242      3.33E-03     1.09E-03     1.33E-03     4.67E-03     2.43E-03
 CM-244      6.20E 00     2.02E 00     6.09E 00     1.23E 01     8.10E 00
```

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TABLE 2 - 14 : TIME PERIOD=       100.

NUCLIDE      HIGH POP     LOW POP      NON-SPEC     TOT-HIGH     TOT-LOW
   C-14      1.14E-06     3.48E-07     1.11E-05     1.22E-05     1.14E-05
  SR-90      7.28E 00     2.26E 00     1.27E 01     2.00E 01     1.50E 01
   Y-90      6.80E-02     2.08E-02     5.99E-02     1.28E-01     8.07E-02
  ZR-93      4.77E-07     1.49E-07     2.52E-06     2.99E-06     2.66E-06
 NB-93M      7.58E-07     2.35E-07     2.95E-05     3.03E-05     2.98E-05
  TC-99      1.16E-05     3.58E-06     7.34E-04     7.45E-04     7.37E-04
  I-129      2.12E-09     6.86E-10     1.75E-09     3.87E-09     2.43E-09
 CS-135      2.27E-06     6.91E-07     1.81E-05     2.04E-05     1.88E-05
 CS-137      6.61E-01     2.03E-01     4.64E 00     5.30E 00     4.85E 00
 PB-210      6.00E-09     1.86E-09     7.42E-09     1.34E-08     9.28E-09
 RA-225      2.65E-07     8.09E-08     2.52E-06     2.78E-06     2.60E-06
 RA-226      8.38E-08     2.56E-08     1.00E-06     1.09E-06     1.03E-06
 TH-229      7.39E-06     2.41E-06     4.44E-07     7.84E-06     2.85E-06
 TH-230      7.07E-07     2.31E-07     2.38E-08     7.30E-07     2.54E-07
 NP-237      2.16E-03     6.92E-04     8.35E-04     3.00E-03     1.53E-03
 NP-239      1.14E-02     3.71E-03     2.10E-05     1.14E-02     3.73E-03
 PU-238      1.43E 00     4.67E-01     2.37E-02     1.45E 00     4.90E-01
 PU-239      1.24E-02     4.03E-03     2.15E-04     1.26E-02     4.25E-03
 PU-240      2.42E-01     7.90E-02     4.21E-03     2.46E-01     8.32E-02
 PU-241      1.25E-03     4.07E-04     2.90E-05     1.27E-03     4.36E-04
 AM-241      2.41E 00     7.72E-01     9.26E-01     3.34E 00     1.70E 00
AM-242M      1.55E-01     4.94E-02     6.55E-02     2.20E-01     1.15E-01
 AM-243      5.36E-01     1.72E-01     2.07E-01     7.44E-01     3.79E-01
 CM-242      8.28E-03     2.69E-03     1.08E-03     9.37E-03     3.77E-03
 CM-244      2.96E 00     9.51E-01     9.57E-01     3.92E 00     1.91E 00
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Appendix P

Table P-10. AMRAW-B Output Table 3

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        TABLE 3 : DISCOUNTED PRESENT VALUES ( $ )
                  DISCOUNT RATE = 0.00 %

                HIGH POPULATION                 LOW POPULATION
NUCLIDE       DISCOUNTED      PV $/GM       DISCOUNTED      PV $/GM

  PU-240      0.37E 06                      0.12E 06
  CM-244      0.96E 03                      0.52E 03
 SUB TOT      3.72E 05      8.51E-03        1.21E 05      2.77E-03
  RA-225      0.72E 07                      0.66E 07
  TH-229      0.18E 08                      0.57E 07
  NP-237      0.68E 09                      0.27E 09
  PU-241      0.58E 03                      0.19E 03
  AM-241      0.90E 05                      0.30E 05
 SUB TOT      7.06E 08      6.82E 00        2.82E 08      2.72E 00
  PB-210      0.99E 06                      0.45E 06
  RA-226      0.63E 08                      0.58E 08
  TH-230      0.11E 07                      0.37E 06
  PU-238      0.88E 03                      0.29E 03
 AM-242M      0.22E 03                      0.84E 02
  CM-242      0.11E 02                      0.36E 01
 SUB TOT      6.52E 07      1.00E 01        5.89E 07      9.06E 00
  NP-239      0.15E 05                      0.51E 04
  PU-239      0.25E 07                      0.80E 06
  AM-243      0.10E 07                      0.34E 06
 SUB TOT      3.51E 06      4.41E-02        1.15E 06      1.44E-02
    C-14      0.32E 02                      0.30E 02
 SUB TOT      3.16E 01      7.83E-04        2.98E 01      7.37E-04
   SR-90      0.42E 04                      0.31E 04
    Y-90      0.28E 02                      0.17E 02
 SUB TOT      4.21E 03      6.70E-05        3.16E 03      5.03E-05
   ZR-93      0.25E 04                      0.21E 04
  NB-93M      0.32E 05                      0.31E 05
 SUB TOT      3.46E 04      2.60E-04        3.35E 04      2.52E-04
   TC-99      0.48E 09                      0.47E 09
 SUB TOT      4.82E 08      3.13E 00        4.73E 08      3.07E 00
   I-129      0.46E 04                      0.36E 04
 SUB TOT      4.58E 03      7.85E-02        3.58E 03      6.13E-02
  CS-135      0.26E 05                      0.23E 05
 SUB TOT      2.56E 04      3.76E-04        2.30E 04      3.38E-04
  CS-137      0.12E 04                      0.11E 04
 SUB TOT      1.17E 03      7.69E-06        1.07E 03      7.01E-06
TOTAL         1.26E 09      1.57E 00        8.15E 08      1.01E 00
```

Appendix P

Table P-11 AMRAW-B Output Table 4-1

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                      TABLE 4 - 1 : HIGH POPULATION SCENARIO
                NUMBER OF DEATHS PER TIME INTERVAL.(8260000.)
   TIME    REPO      EDDY      RCOD      MIDJ      WTC       LEA       CHAV      REGB      TOT.ZONE  NON-SPEC  TTOTAL

      0.   0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
      5.   0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
     10.   0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
     15.   0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
     20.   0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
     25.   0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
     30.   0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
     40.   6.19E-06  9.32E-05  6.06E-05  1.94E-05  9.01E-06  7.44E-05  8.76E-05  1.53E-04  5.03E-04  2.31E-03  2.81E-03
     50.   6.55E-06  1.42E-04  8.93E-05  2.55E-05  1.17E-05  9.51E-05  1.31E-04  1.85E-04  6.87E-04  1.53E-03  2.62E-03
     60.   6.51E-06  1.67E-04  1.02E-04  2.79E-05  1.27E-05  1.03E-04  1.50E-04  1.83E-04  7.53E-04  1.62E-03  2.37E-03
     70.   6.23E-06  1.74E-04  1.04E-04  2.82E-05  1.28E-05  1.04E-04  1.54E-04  1.65E-04  7.51E-04  1.35E-03  2.10E-03
     80.   5.85E-06  1.70E-04  1.00E-04  2.75E-05  1.25E-05  1.01E-04  1.47E-04  1.50E-04  7.15E-04  1.12E-03  1.83E-03
     90.   5.49E-06  1.61E-04  9.24E-05  2.64E-05  1.20E-05  9.67E-05  1.36E-04  1.33E-04  6.63E-04  9.22E-04  1.58E-03
    100.   5.17E-06  1.48E-04  8.35E-05  2.54E-05  1.15E-05  9.29E-05  1.22E-04  1.19E-04  6.07E-04  7.55E-04  1.36E-03
    200.   7.63E-05  1.88E-03  9.34E-04  4.00E-04  1.81E-04  1.45E-03  1.31E-03  2.35E-03  8.59E-03  5.38E-03  1.42E-02
    300.   6.67E-05  7.49E-04  4.92E-04  3.64E-04  1.64E-04  1.32E-03  6.18E-04  1.41E-03  5.19E-03  9.23E-04  6.11E-03
    400.   7.29E-05  7.08E-04  5.24E-04  4.01E-04  1.81E-04  1.45E-03  6.52E-04  1.47E-03  5.46E-03  4.26E-04  5.89E-03
    500.   7.86E-05  7.76E-04  5.80E-04  4.37E-04  1.98E-04  1.59E-03  7.27E-04  1.57E-03  5.95E-03  3.47E-04  6.30E-03
    600.   8.41E-05  8.40E-04  6.29E-04  4.70E-04  2.12E-04  1.70E-03  7.89E-04  1.65E-03  6.38E-03  3.17E-04  6.70E-03
    700.   8.87E-05  8.87E-04  6.64E-04  4.97E-04  2.24E-04  1.80E-03  8.33E-04  1.72E-03  6.71E-03  2.94E-04  7.00E-03
    800.   9.22E-05  9.16E-04  6.87E-04  5.17E-04  2.34E-04  1.87E-03  8.59E-04  1.75E-03  6.94E-03  2.72E-04  7.21E-03
    900.   9.46E-05  9.31E-04  7.00E-04  5.32E-04  2.40E-04  1.93E-03  8.74E-04  1.79E-03  7.09E-03  2.52E-04  7.34E-03
   1000.   9.65E-05  9.38E-04  7.07E-04  5.43E-04  2.45E-04  1.97E-03  8.80E-04  1.81E-03  7.19E-03  2.34E-04  7.42E-03
   2000.   1.52E-03  1.41E-02  1.08E-02  8.60E-03  3.89E-03  3.11E-02  1.32E-02  3.17E-02  1.15E-01  2.25E-03  1.17E-01
   3000.   1.62E-03  1.38E-02  1.08E-02  9.21E-03  4.15E-03  3.33E-02  1.30E-02  3.28E-02  1.19E-01  1.88E-03  1.21E-01
   4000.   1.89E-03  1.56E-02  1.22E-02  1.07E-02  4.84E-03  3.87E-02  1.46E-02  3.72E-02  1.36E-01  2.07E-03  1.38E-01
   5000.   2.13E-03  1.73E-02  1.37E-02  1.21E-02  5.46E-03  4.38E-02  1.63E-02  4.12E-02  1.52E-01  2.40E-03  1.54E-01
   6000.   2.34E-03  1.87E-02  1.48E-02  1.33E-02  5.99E-03  4.80E-02  1.76E-02  4.46E-02  1.65E-01  2.94E-03  1.68E-01
   7000.   2.50E-03  1.99E-02  1.58E-02  1.42E-02  6.41E-03  5.15E-02  1.86E-02  4.72E-02  1.76E-01  4.81E-03  1.81E-01
   8000.   2.63E-03  2.08E-02  1.65E-02  1.50E-02  6.76E-03  5.42E-02  1.94E-02  4.93E-02  1.85E-01  1.45E-02  1.99E-01
   9000.   2.74E-03  2.16E-02  1.70E-02  1.56E-02  7.04E-03  5.64E-02  2.00E-02  5.10E-02  1.91E-01  4.56E-02  2.37E-01
  10000.   2.83E-03  2.25E-02  1.75E-02  1.61E-02  7.27E-03  5.83E-02  2.04E-02  5.23E-02  1.97E-01  9.38E-02  2.91E-01
  20000.   4.25E-02  3.23E-01  2.55E-01  2.41E-01  1.09E-01  8.72E-01  2.95E-01  8.56E-01  2.99E 00  1.39E 00  4.38E 00
  30000.   3.29E-02  2.57E-01  1.81E-01  1.86E-01  8.41E-02  6.73E-01  2.03E-01  6.51E-01  2.27E 00  5.91E 00  8.18E 00
  40000.   2.52E-02  2.09E-01  1.28E-01  1.43E-01  6.43E-02  5.16E-01  1.38E-01  7.10E-01  1.93E 00  1.17E 01  1.36E 01
  50000.   2.06E-02  1.93E-01  1.01E-01  1.17E-01  5.27E-02  4.22E-01  1.08E-01  7.77E-01  1.79E 00  1.59E 01  1.77E 01
  60000.   1.73E-02  1.91E-01  8.79E-02  9.82E-02  4.44E-02  3.56E-01  9.51E-02  7.72E-01  1.66E 00  1.82E 01  1.99E 01
  70000.   1.46E-02  1.94E-01  8.01E-02  8.27E-02  3.74E-02  3.00E-01  8.96E-02  7.37E-01  1.53E 00  1.96E 01  2.12E 01
  80000.   1.22E-02  1.96E-01  7.45E-02  6.93E-02  3.13E-02  2.51E-01  8.69E-02  6.92E-01  1.41E 00  2.04E 01  2.18E 01
  90000.   1.02E-02  1.98E-01  7.03E-02  5.83E-02  2.63E-02  2.11E-01  8.54E-02  6.45E-01  1.31E 00  2.09E 01  2.21E 01
 100000.   8.72E-03  1.99E-01  6.76E-02  4.96E-02  2.24E-02  1.80E-01  8.51E-02  6.13E-01  1.23E 00  2.10E 01  2.22E 01
 200000.   1.72E-01  2.63E 00  1.66E 00  9.79E-01  4.41E-01  3.54E 00  2.21E 00  5.77E 00  1.74E 01  9.16E 01  1.09E 02
 300000.   1.46E-01  4.71E 00  1.61E 00  8.31E-01  3.76E-01  3.01E 00  2.19E 00  1.66E 01  2.95E 01  5.07E 02  5.37E 02
 400000.   1.59E-01  4.06E 00  1.54E 00  9.07E-01  4.09E-01  3.28E 00  2.05E 00  1.40E 01  2.64E 01  4.01E 02  4.27E 02
 500000.   1.66E-01  3.29E 00  1.42E 00  9.41E-01  4.25E-01  3.41E 00  1.84E 00  1.11E 01  2.25E 01  2.91E 02  3.14E 02
 600000.   1.67E-01  2.67E 00  1.29E 00  9.47E-01  4.28E-01  3.43E 00  1.62E 00  8.89E 00  1.94E 01  2.09E 02  2.28E 02
 700000.   1.65E-01  2.20E 00  1.17E 00  9.39E-01  4.24E-01  3.40E 00  1.43E 00  7.28E 00  1.70E 01  1.51E 02  1.68E 02
 800000.   1.62E-01  4.06E 00  1.06E 00  9.19E-01  4.15E-01  3.32E 00  1.28E 00  6.10E 00  1.73E 01  1.10E 02  1.20E 02
 900000.   1.56E-01  1.52E 02  9.74E-01  8.90E-01  4.02E-01  3.22E 00  1.14E 00  5.20E 00  1.34E 02  9.16E 01  2.55E 02
1000000.   1.51E-01  2.29E 03  8.98E-01  8.59E-01  3.88E-01  3.11E 00  1.04E 00  4.53E 00  2.30E 03  2.13E 02  2.52E 03
TOTAL      1.65E 00  2.47E 03  1.28E 01  9.38E 00  4.23E 00  3.39E 01  1.61E 01  8.63E 01  2.63E 03  2.21E 03  4.04E 03
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Table P-12. AMRAW-B Output Table 4-2

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                   TABLE 4 - 2 : LOW POPULATION SCENARIO
              NUMBER OF DEATHS PER TIME INTERVAL.(8260000.)

    TIME REPO      EDDY      REBO      MIDO      WTE       LEA       CHAV      REGA      TOT.ZONE  NON-SPEC  TTOTAL

      0. 0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
      5. 0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
     10. 0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
     15. 0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
     20. 0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
     25. 0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
     30. 0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
     40. 6.19E-06  3.30E-05  1.53E-05  5.56E-06  2.41E-06  2.25E-05  2.35E-05  5.41E-05  1.63E-04  2.31E-03  2.47E-03
     50. 6.55E-06  5.05E-05  2.25E-05  7.27E-06  3.11E-06  2.87E-05  3.51E-05  6.57E-05  2.19E-04  1.93E-03  2.15E-03
     60. 6.51E-06  5.91E-05  2.57E-05  7.96E-06  3.39E-06  3.12E-05  4.03E-05  6.49E-05  2.39E-04  1.62E-03  1.86E-03
     70. 6.23E-06  6.17E-05  2.62E-05  8.07E-06  3.43E-06  3.14E-05  4.12E-05  5.96E-05  2.38E-04  1.35E-03  1.59E-03
     80. 5.85E-06  6.05E-05  2.52E-05  7.86E-06  3.33E-06  3.05E-05  3.95E-05  5.32E-05  2.26E-04  1.12E-03  1.34E-03
     90. 5.49E-06  5.70E-05  2.32E-05  7.54E-06  3.20E-06  2.92E-05  3.64E-05  4.72E-05  2.09E-04  9.22E-04  1.13E-03
    100. 5.17E-06  5.23E-05  2.10E-05  7.25E-06  3.07E-06  2.81E-05  3.27E-05  4.22E-05  1.92E-04  7.55E-04  9.46E-04
    200. 7.63E-05  6.67E-04  2.35E-04  1.14E-04  4.63E-05  4.39E-04  3.51E-04  8.32E-04  2.76E-03  5.58E-03  8.34E-03
    300. 6.67E-05  2.66E-04  1.24E-04  1.04E-04  4.39E-05  3.99E-04  1.66E-04  5.01E-04  1.67E-03  9.23E-04  2.59E-03
    400. 7.25E-05  2.51E-04  1.32E-04  1.15E-04  4.84E-05  4.39E-04  1.75E-04  5.20E-04  1.75E-03  4.26E-04  2.18E-03
    500. 7.86E-05  2.75E-04  1.46E-04  1.25E-04  5.27E-05  4.79E-04  1.95E-04  5.55E-04  1.91E-03  3.47E-04  2.25E-03
    600. 8.41E-05  2.98E-04  1.58E-04  1.34E-04  5.67E-05  5.15E-04  2.11E-04  5.84E-04  2.04E-03  3.17E-04  2.36E-03
    700. 8.87E-05  3.15E-04  1.67E-04  1.42E-04  5.99E-05  5.44E-04  2.23E-04  6.08E-04  2.15E-03  2.94E-04  2.44E-03
    800. 9.22E-05  3.25E-04  1.73E-04  1.48E-04  6.23E-05  5.66E-04  2.30E-04  6.25E-04  2.22E-03  2.72E-04  2.49E-03
    900. 9.46E-05  3.30E-04  1.76E-04  1.52E-04  6.41E-05  5.82E-04  2.34E-04  6.35E-04  2.27E-03  2.52E-04  2.52E-03
   1000. 9.65E-05  3.32E-04  1.78E-04  1.55E-04  6.55E-05  5.95E-04  2.36E-04  6.41E-04  2.30E-03  2.34E-04  2.53E-03
   2000. 1.52E-03  5.01E-03  2.71E-03  2.46E-03  1.04E-03  9.40E-03  3.55E-03  1.12E-02  3.69E-02  2.25E-03  3.92E-02
   3000. 1.62E-03  4.90E-03  2.71E-03  2.63E-03  1.11E-03  1.01E-02  3.47E-03  1.16E-02  3.81E-02  1.89E-03  4.00E-02
   4000. 1.89E-03  5.53E-03  3.08E-03  3.05E-03  1.29E-03  1.17E-02  3.92E-03  1.32E-02  4.36E-02  2.07E-03  4.57E-02
   5000. 2.13E-03  6.15E-03  3.44E-03  3.46E-03  1.46E-03  1.32E-02  4.36E-03  1.46E-02  4.88E-02  2.40E-03  5.12E-02
   6000. 2.34E-03  6.63E-03  3.73E-03  3.79E-03  1.60E-03  1.45E-02  4.71E-03  1.58E-02  5.31E-02  2.94E-03  5.60E-02
   7000. 2.50E-03  7.05E-03  3.96E-03  4.06E-03  1.71E-03  1.55E-02  5.00E-03  1.67E-02  5.65E-02  4.81E-03  6.13E-02
   8000. 2.63E-03  7.37E-03  4.15E-03  4.28E-03  1.80E-03  1.64E-02  5.21E-03  1.75E-02  5.93E-02  1.45E-02  7.38E-02
   9000. 2.74E-03  7.67E-03  4.29E-03  4.45E-03  1.88E-03  1.70E-02  5.35E-03  1.81E-02  6.15E-02  4.56E-02  1.07E-01
  10000. 2.83E-03  7.97E-03  4.40E-03  4.60E-03  1.94E-03  1.76E-02  5.48E-03  1.85E-02  6.33E-02  9.38E-02  1.57E-01
  20000. 4.25E-02  1.15E-01  6.41E-02  6.89E-02  2.90E-02  2.63E-01  7.91E-02  3.03E-01  9.65E-01  1.39E 00  2.35E 00
  30000. 3.29E-02  9.12E-02  4.56E-02  5.31E-02  2.24E-02  2.03E-01  5.45E-02  2.31E-01  7.34E-01  5.91E 00  6.65E 00
  40000. 2.52E-02  7.42E-02  3.21E-02  4.08E-02  1.72E-02  1.56E-01  3.69E-02  2.52E-01  6.34E-01  1.17E 01  1.23E 01
  50000. 2.06E-02  6.85E-02  2.55E-02  3.33E-02  1.41E-02  1.28E-01  2.86E-02  2.75E-01  5.94E-01  1.59E 01  1.65E 01
  60000. 1.73E-02  6.79E-02  2.21E-02  2.81E-02  1.18E-02  1.07E-01  2.55E-02  2.74E-01  5.54E-01  1.82E 01  1.88E 01
  70000. 1.46E-02  6.87E-02  2.02E-02  2.36E-02  9.97E-03  9.05E-02  2.40E-02  2.61E-01  5.12E-01  1.96E 01  2.01E 01
  80000. 1.22E-02  6.96E-02  1.87E-02  1.98E-02  8.35E-03  7.58E-02  2.33E-02  2.45E-01  4.73E-01  2.04E 01  2.09E 01
  90000. 1.02E-02  7.01E-02  1.77E-02  1.66E-02  7.02E-03  6.36E-02  2.29E-02  2.30E-01  4.38E-01  2.08E 01  2.12E 01
 100000. 8.72E-03  7.06E-02  1.70E-02  1.42E-02  5.98E-03  5.43E-02  2.28E-02  2.17E-01  4.11E-01  2.10E 01  2.14E 01
 200000. 1.72E-01  9.33E-01  4.18E-01  2.80E-01  1.18E-01  1.07E 00  5.91E-01  2.04E 00  5.62E 00  9.16E 01  9.72E 01
 300000. 1.46E-01  1.67E 00  4.05E-01  2.38E-01  1.00E-01  9.09E-01  5.87E-01  5.90E 00  9.95E 00  5.07E 02  5.17E 02
 400000. 1.59E-01  1.44E 00  3.88E-01  2.59E-01  1.09E-01  9.91E-01  5.50E-01  4.95E 00  8.85E 00  4.01E 02  4.10E 02
 500000. 1.66E-01  1.17E 00  3.57E-01  2.69E-01  1.13E-01  1.03E 00  4.92E-01  3.92E 00  7.51E 00  2.91E 02  2.99E 02
 600000. 1.67E-01  9.46E-01  3.24E-01  2.71E-01  1.14E-01  1.04E 00  4.34E-01  3.15E 00  6.44E 00  2.09E 02  2.15E 02
 700000. 1.65E-01  7.80E-01  2.94E-01  2.68E-01  1.13E-01  1.03E 00  3.84E-01  2.58E 00  5.61E 00  1.51E 02  1.57E 02
 800000. 1.62E-01  1.44E 00  2.68E-01  2.63E-01  1.11E-01  1.00E 00  3.42E-01  2.16E 00  5.75E 00  1.10E 02  1.16E 02
 900000. 1.56E-01  5.38E 01  2.45E-01  2.54E-01  1.07E-01  9.74E-01  3.07E-01  1.84E 00  5.77E 01  9.16E 01  1.49E 02
1000000. 1.51E-01  8.12E 02  2.26E-01  2.43E-01  1.03E-01  9.39E-01  2.78E-01  1.60E 00  8.15E 02  2.18E 02  1.03E 03
TOTAL    1.65E 00  8.75E 02  3.22E 00  2.68E 00  1.13E 00  1.03E 01  4.33E 00  3.06E 01  9.29E 02  2.21E 03  3.13E 03
```

Appendix P.

Table P-13. AMRAW-B Output Table 5-1

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TABLE 5 - 1 : TOTAL UNDISCOUNTED DAMAGES FOR EACH ZONE FOR EACH TIME INTERVAL - HIGH POPULATION
TIME      REPO        EDDY        FEDO        MIDO        WTE         LZA         CHAV        RTGB        TOT.ZONE    NON-SPEC    TTOTAL
      0.  0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0
      5.  0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0
     10.  0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0
     15.  0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0
     20.  0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0
     25.  0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0
     30.  0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0
     40.  1.61E 00    2.42E 01    1.58E 01    5.06E 00    2.34E 00    1.53E 01    2.28E 01    3.97E 01    1.31E 02    6.00E 02    7.30E 02
     50.  1.70E 00    3.70E 01    2.32E 01    6.62E 00    3.03E 00    2.47E 01    3.41E 01    4.82E 01    1.79E 02    5.02E 02    6.80E 02
     60.  1.69E 00    4.33E 01    2.65E 01    7.25E 00    3.31E 00    2.60E 01    3.91E 01    4.76E 01    1.96E 02    4.22E 02    6.17E 02
     70.  1.62E 00    4.52E 01    2.71E 01    7.34E 00    3.34E 00    2.70E 01    4.00E 01    4.37E 01    1.95E 02    3.51E 02    5.46E 02
     80.  1.52E 00    4.43E 01    2.60E 01    7.15E 00    3.25E 00    2.63E 01    3.83E 01    3.91E 01    1.86E 02    2.91E 02    4.77E 02
     90.  1.43E 00    4.18E 01    2.40E 01    6.86E 00    3.12E 00    2.51E 01    3.53E 01    3.47E 01    1.72E 02    2.40E 02    4.12E 02
    100.  1.35E 00    3.84E 01    2.17E 01    6.59E 00    2.99E 00    2.42E 01    3.17E 01    3.10E 01    1.58E 02    1.96E 02    3.54E 02
    200.  1.98E 01    4.89E 02    2.43E 02    1.04E 02    4.71E 01    3.70E 02    3.41E 02    6.11E 02    2.23E 03    1.45E 03    3.68E 03
    300.  1.74E 01    1.95E 02    1.28E 02    9.46E 01    4.28E 01    3.43E 02    1.61E 02    3.67E 02    1.35E 03    2.40E 02    1.59E 03
    400.  1.89E 01    1.84E 02    1.36E 02    1.04E 02    4.71E 01    3.78E 02    1.70E 02    3.81E 02    1.42E 03    1.11E 02    1.53E 03
    500.  2.04E 01    2.02E 02    1.51E 02    1.14E 02    5.14E 01    4.12E 02    1.89E 02    4.07E 02    1.55E 03    9.03E 01    1.64E 03
    600.  2.19E 01    2.18E 02    1.63E 02    1.22E 02    5.52E 01    4.43E 02    2.05E 02    4.29E 02    1.66E 03    8.25E 01    1.74E 03
    700.  2.31E 01    2.31E 02    1.73E 02    1.29E 02    5.84E 01    4.68E 02    2.16E 02    4.46E 02    1.74E 03    7.64E 01    1.82E 03
    800.  2.40E 01    2.38E 02    1.79E 02    1.34E 02    6.07E 01    4.87E 02    2.23E 02    4.59E 02    1.81E 03    7.06E 01    1.88E 03
    900.  2.46E 01    2.42E 02    1.82E 02    1.38E 02    6.25E 01    5.01E 02    2.27E 02    4.66E 02    1.84E 03    6.54E 01    1.91E 03
   1000.  2.51E 01    2.44E 02    1.84E 02    1.41E 02    6.38E 01    5.12E 02    2.29E 02    4.71E 02    1.87E 03    6.07E 01    1.93E 03
   2000.  3.95E 02    3.67E 03    2.80E 03    2.24E 03    1.01E 03    8.09E 03    3.44E 03    8.25E 03    2.99E 04    5.05E 02    3.05E 04
   3000.  4.22E 02    3.60E 03    2.80E 03    2.40E 03    1.08E 03    8.66E 03    3.37E 03    8.53E 03    3.08E 04    4.89E 02    3.13E 04
   4000.  4.91E 02    4.05E 03    3.18E 03    2.78E 03    1.26E 03    1.01E 04    3.80E 03    9.65E 03    3.53E 04    5.39E 02    3.59E 04
   5000.  5.54E 02    4.51E 03    3.55E 03    3.15E 03    1.42E 03    1.14E 04    4.23E 03    1.07E 04    3.95E 04    6.23E 02    4.02E 04
   6000.  6.07E 02    4.86E 03    3.86E 03    3.45E 03    1.56E 03    1.25E 04    4.57E 03    1.16E 04    4.30E 04    7.65E 02    4.37E 04
   7000.  6.50E 02    5.17E 03    4.10E 03    3.69E 03    1.67E 03    1.34E 04    4.85E 03    1.23E 04    4.56E 04    1.25E 03    4.70E 04
   8000.  6.85E 02    5.40E 03    4.29E 03    3.89E 03    1.76E 03    1.41E 04    5.09E 03    1.28E 04    4.80E 04    3.78E 03    5.18E 04
   9000.  7.13E 02    5.62E 03    4.43E 03    4.05E 03    1.83E 03    1.47E 04    5.19E 03    1.33E 04    4.98E 04    1.10E 04    6.10E 04
  10000.  7.36E 02    5.84E 03    4.55E 03    4.18E 03    1.89E 03    1.52E 04    5.31E 03    1.36E 04    5.13E 04    2.44E 04    7.57E 04
  20000.  1.11E 04    8.41E 04    6.62E 04    6.27E 04    2.83E 04    2.27E 05    7.67E 04    2.22E 05    7.78E 05    3.61E 05    1.14E 06
  30000.  8.54E 03    6.68E 04    4.71E 04    4.84E 04    2.19E 04    1.75E 05    5.29E 04    1.69E 05    5.90E 05    1.54E 06    2.13E 06
  40000.  6.54E 03    5.44E 04    3.32E 04    3.71E 04    1.67E 04    1.34E 05    3.58E 04    1.85E 05    5.03E 05    3.03E 06    3.54E 06
  50000.  6.34E 03    5.02E 04    2.63E 04    3.03E 04    1.37E 04    1.10E 05    2.80E 04    2.02E 05    4.66E 05    4.13E 06    4.60E 06
  60000.  4.50E 03    4.98E 04    2.29E 04    2.55E 04    1.15E 04    9.25E 04    2.47E 04    2.01E 05    4.32E 05    4.74E 06    5.18E 06
  70000.  3.78E 03    5.04E 04    2.08E 04    2.15E 04    9.71E 03    7.79E 04    2.33E 04    1.91E 05    3.99E 05    5.10E 06    5.50E 06
  80000.  3.18E 03    5.10E 04    1.94E 04    1.80E 04    8.14E 03    6.53E 04    2.26E 04    1.80E 05    3.67E 05    5.30E 06    5.67E 06
  90000.  2.66E 03    5.14E 04    1.83E 04    1.51E 04    6.84E 03    5.48E 04    2.22E 04    1.69E 05    3.40E 05    5.41E 06    5.75E 06
 100000.  2.27E 03    5.18E 04    1.76E 04    1.29E 04    5.83E 03    4.67E 04    2.21E 04    1.59E 05    3.19E 05    5.47E 06    5.78E 06
 200000.  4.47E 04    6.84E 05    4.32E 05    2.54E 05    1.15E 05    9.20E 05    5.73E 05    1.53E 06    4.52E 06    2.30E 07    2.83E 07
 300000.  3.80E 04    1.23E 06    4.18E 05    2.16E 05    9.78E 04    7.82E 05    5.70E 05    4.33E 06    7.68E 06    1.32E 08    1.39E 08
 400000.  4.14E 04    1.05E 06    4.01E 05    2.36E 05    1.06E 05    8.53E 05    5.34E 05    3.63E 06    6.86E 06    1.04E 08    1.11E 08
 500000.  4.30E 04    8.55E 05    3.69E 05    2.45E 05    1.10E 05    8.87E 05    4.77E 05    2.89E 06    5.86E 06    7.57E 07    8.16E 07
 600000.  4.34E 04    6.93E 05    3.35E 05    2.46E 05    1.11E 05    8.92E 05    4.21E 05    2.31E 06    5.05E 06    5.43E 07    5.93E 07
 700000.  4.29E 04    5.72E 05    3.03E 05    2.44E 05    1.10E 05    8.84E 05    3.72E 05    1.89E 06    4.42E 06    3.92E 07    4.37E 07
 800000.  4.20E 04    1.06E 06    2.76E 05    2.39E 05    1.08E 05    8.63E 05    3.32E 05    1.59E 06    4.50E 06    2.87E 07    3.32E 07
 900000.  4.07E 04    3.94E 07    2.53E 05    2.31E 05    1.05E 05    8.38E 05    2.97E 05    1.35E 06    4.25E 07    2.38E 07    6.64E 07
1000000.  3.92E 04    5.95E 08    2.33E 05    2.23E 05    1.01E 05    8.09E 05    2.70E 05    1.18E 06    5.98E 08    5.66E 07    6.55E 08
TOTAL     4.29E 05    6.41E 08    3.33E 06    2.44E 06    1.10E 06    8.82E 06    4.20E 06    2.24E 07    6.84E 08    5.73E 08    1.26E 09
```

Appendix P.

Table P-14. AMRAW-B Output Table 5-2

```
TABLE 5 - 2 : TOTAL UNDISCOUNTED DAMAGES FOR EACH ZONE FOR EACH TIME INTERVAL -  LOW POPULATION
TIME      PEPO       EDDY       REBO       HIDO       WTE        LEA        CHAV       REGB       TOT.ZONE   NON-SPEC   TTOTAL
      0.  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
      5.  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     10.  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     15.  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     20.  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     25.  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     30.  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     40.  1.61E 00   8.59E 00   3.97E 00   1.44E 00   6.25E-01   5.84E 00   6.10E 00   1.41E 01   4.23E 01   6.00E 02   6.42E 02
     50.  1.70E 00   1.31E 01   5.04E 00   1.89E 00   8.09E-01   7.47E 00   9.14E 00   1.71E 01   5.71E 01   5.02E 02   5.59E 02
     60.  1.69E 00   1.54E 01   6.00E 00   2.07E 00   8.82E-01   8.11E 00   1.05E 01   1.69E 01   6.21E 01   4.22E 02   4.84E 02
     70.  1.62E 00   1.60E 01   6.81E 00   2.10E 00   8.91E-01   8.16E 00   1.07E 01   1.55E 01   6.18E 01   3.51E 02   4.13E 02
     80.  1.52E 00   1.57E 01   6.54E 00   2.04E 00   8.66E-01   7.53E 00   1.03E 01   1.38E 01   5.87E 01   2.91E 02   3.50E 02
     90.  1.43E 00   1.48E 01   6.04E 00   1.96E 00   8.32E-01   7.60E 00   9.45E 00   1.23E 01   5.44E 01   2.40E 02   2.94E 02
    100.  1.35E 00   1.36E 01   5.46E 00   1.88E 00   7.98E-01   7.30E 00   8.50E 00   1.10E 01   4.99E 01   1.96E 02   2.46E 02
    200.  1.98E 01   1.74E 02   6.11E 01   2.57E 01   1.20E 01   1.14E 02   9.13E 01   2.16E 02   7.19E 02   1.45E 03   2.17E 03
    300.  1.74E 01   6.91E 01   3.22E 01   2.70E 01   1.14E 01   1.08E 02   4.31E 01   1.30E 02   4.34E 02   2.40E 02   6.74E 02
    400.  1.89E 01   6.53E 01   3.43E 01   2.98E 01   1.26E 01   1.16E 02   4.59E 01   1.33E 02   4.56E 02   1.11E 02   5.66E 02
    500.  2.04E 01   7.16E 01   3.80E 01   3.23E 01   1.37E 01   1.25E 02   5.06E 01   1.44E 02   4.96E 02   9.03E 01   5.86E 02
    600.  2.19E 01   7.75E 01   4.11E 01   3.49E 01   1.47E 01   1.34E 02   5.49E 01   1.52E 02   5.31E 02   8.25E 01   6.13E 02
    700.  2.31E 01   8.10E 01   4.34E 01   3.69E 01   1.56E 01   1.41E 02   5.80E 01   1.58E 02   5.58E 02   7.64E 01   6.35E 02
    800.  2.40E 01   8.44E 01   4.50E 01   3.84E 01   1.62E 01   1.47E 02   5.99E 01   1.62E 02   5.77E 02   7.08E 01   6.48E 02
    900.  2.48E 01   8.50E 01   4.58E 01   3.93E 01   1.67E 01   1.51E 02   6.09E 01   1.65E 02   5.90E 02   6.54E 01   6.55E 02
   1000.  2.51E 01   8.84E 01   4.63E 01   4.04E 01   1.70E 01   1.55E 02   6.13E 01   1.67E 02   5.98E 02   6.07E 01   6.59E 02
   2000.  3.95E 02   1.30E 03   7.05E 02   6.39E 02   2.70E 02   2.44E 03   9.23E 02   2.92E 03   9.60E 03   5.86E 02   1.02E 04
   3000.  4.22E 02   1.28E 03   7.09E 02   6.84E 02   2.88E 02   2.61E 03   9.02E 02   3.02E 03   9.91E 03   4.89E 02   1.04E 04
   4000.  4.91E 02   1.44E 03   8.01E 02   7.94E 02   3.36E 02   3.04E 03   1.02E 03   3.43E 03   1.13E 04   5.39E 02   1.19E 04
   5000.  5.54E 02   1.60E 03   8.94E 02   9.00E 02   3.79E 02   3.44E 03   1.13E 03   3.80E 03   1.27E 04   6.23E 02   1.33E 04
   6000.  6.07E 02   1.72E 03   9.70E 02   9.86E 02   4.15E 02   3.77E 03   1.23E 03   4.10E 03   1.38E 04   7.65E 02   1.46E 04
   7000.  6.50E 02   1.83E 03   1.03E 03   1.05E 03   4.43E 02   4.04E 03   1.30E 03   4.34E 03   1.47E 04   1.23E 03   1.59E 04
   8000.  6.85E 02   1.92E 03   1.08E 03   1.11E 03   4.69E 02   4.25E 03   1.35E 03   4.54E 03   1.54E 04   3.78E 03   1.92E 04
   9000.  7.13E 02   1.99E 03   1.11E 03   1.15E 03   4.88E 02   4.43E 03   1.39E 03   4.69E 03   1.60E 04   1.18E 04   2.78E 04
  10000.  7.36E 02   2.07E 03   1.14E 03   1.20E 03   5.04E 02   4.58E 03   1.42E 03   4.81E 03   1.65E 04   2.44E 04   4.09E 04
  20000.  1.11E 04   2.98E 04   1.67E 04   1.79E 04   7.54E 03   6.85E 04   2.06E 04   7.88E 04   2.51E 05   3.61E 05   6.12E 05
  30000.  8.56E 03   2.37E 04   1.19E 04   1.38E 04   5.83E 03   5.29E 04   1.42E 04   6.30E 04   1.91E 05   1.54E 06   1.73E 06
  40000.  6.54E 03   1.93E 04   8.35E 03   1.06E 04   4.46E 03   4.05E 04   9.59E 03   6.54E 04   1.65E 05   3.03E 06   3.20E 06
  50000.  5.34E 03   1.70E 04   6.62E 03   8.66E 03   3.69E 03   3.32E 04   7.49E 03   7.16E 04   1.54E 05   4.13E 06   4.28E 06
  60000.  4.50E 03   1.77E 04   5.75E 03   7.30E 03   3.08E 03   2.79E 04   6.63E 03   7.11E 04   1.44E 05   4.74E 06   4.89E 06
  70000.  3.78E 03   1.79E 04   5.24E 03   6.14E 03   2.59E 03   2.35E 04   6.25E 03   6.75E 04   1.33E 05   5.10E 06   5.23E 06
  80000.  3.18E 03   1.81E 04   4.87E 03   5.15E 03   2.17E 03   1.97E 04   6.05E 03   6.37E 04   1.23E 05   5.30E 06   5.43E 06
  90000.  2.66E 03   1.82E 04   4.60E 03   4.33E 03   1.83E 03   1.65E 04   5.95E 03   5.97E 04   1.14E 05   5.41E 06   5.52E 06
 100000.  2.27E 03   1.84E 04   4.42E 03   3.69E 03   1.55E 03   1.41E 04   5.93E 03   5.65E 04   1.07E 05   5.47E 06   5.57E 06
 200000.  4.47E 04   2.43E 05   1.09E 05   7.27E 04   3.06E 04   2.78E 05   1.54E 05   5.31E 05   1.46E 06   2.38E 07   2.53E 07
 300000.  3.80E 04   4.35E 05   1.05E 05   6.16E 04   2.61E 04   2.36E 05   1.53E 05   1.53E 06   2.59E 06   1.32E 08   1.34E 08
 400000.  4.14E 04   3.74E 05   1.01E 05   6.74E 04   2.84E 04   2.58E 05   1.43E 05   1.29E 06   2.30E 06   1.04E 08   1.07E 08
 500000.  4.30E 04   3.03E 05   9.29E 04   6.59E 04   2.55E 04   2.60E 05   1.20E 05   1.02E 06   1.95E 06   7.57E 07   7.77E 07
 600000.  4.34E 04   2.46E 05   8.42E 04   7.03E 04   2.97E 04   2.69E 05   1.13E 05   8.19E 05   1.67E 06   5.43E 07   5.60E 07
 700000.  4.29E 04   2.03E 05   7.64E 04   6.98E 04   2.94E 04   2.67E 05   9.90E 04   6.71E 05   1.46E 06   3.92E 07   4.07E 07
 800000.  4.20E 04   3.74E 05   6.96E 04   6.83E 04   2.88E 04   2.61E 05   8.90E 04   5.62E 05   1.49E 06   2.87E 07   3.02E 07
 900000.  4.07E 04   1.40E 07   6.37E 04   6.61E 04   2.79E 04   2.53E 05   7.97E 04   4.79E 05   1.50E 07   2.38E 07   3.88E 07
1000000.  3.92E 04   2.11E 08   5.87E 04   6.35E 04   2.69E 04   2.44E 05   7.23E 04   4.17E 05   2.12E 08   5.66E 07   2.69E 08
TOTAL     4.29E 05   2.27E 08   8.38E 05   6.97E 05   2.94E 05   2.67E 06   1.12E 06   7.95E 06   2.41E 08   5.73E 08   8.15E 08
```

APPENDIX Q

PROGRAMMER'S NOTES

Variables

The variables used and their definitions are presented in the list of nomenclature in the front pages of this volume.

"Index" File Structure

"Index" is an unformatted temporary file allocated to logical unit 2. Index holds a maximum of 260 records, each 400 bytes in length. Index is calculated for each nuclide and zone.

Number of Zones

The number of geographic zones, designated by the variable MZ, in the initial demonstration is 8. Nonspecific doses and corresponding damages are treated in the calculations as though they are for an additional zone (MZP1 = MZ + 1, or 9 for the demonstration). While input provides for a number of zones other than 8, and the ranges of calculation loops correspond, there are some program changes required for MZ ≠ 8, to provide consistent table formats. For example, in FORMATS 850, 918, and 957, the multiplier of the repeated group (A4, 6X) must be changed from 8 to a new and different value of MZ. Follow-on work can make modifications to automatically accommodate a range of MZ values, but the user is cautioned that these improvements have not yet been made.

Output of Table 2

Table 2 is output (providing the flag ITB3 is set to 1) for all values of time after an initial sequence of times which are bypassed. "IF" statements in lines 1820 and 1900 (numbered on the right side in Appendix R listing) bypass calculations and output for time subscripts through 7 (i.e., through 30 y or subscript 6 in the demonstration). If a different bypass control is desired, the 2 "IF" statements must be modified. It may be desirable in the future to use an input variable for this purpose. This could be the variable NRO suggested in the next paragraph.

Basis for Table 3

Table 3 includes columns of marginal present value costs for decay groups. The values are obtained by dividing the sum of present values of damage for each nuclide in a decay group, \$, by the total mass of nuclides, g, comprising the decay group at a specified time. Presently, the specified time for which mass values, X, are obtained (see input data file AM1E) in the beginning of the terminal storage phase, or a reference time of 30 y (time subscript 7). In a new application, the "7" in lines 2630 and 2670 should be replaced by the integer corresponding to the appropriate time subscript. Line 2290 also uses this time, designated NYRO (number of years of repository operations); this is set equal to 30 in line 402. It may be desirable in the future to use an input variable (e.g., NRO) for the time subscript representing the end of repository operations. This subscript variable could then be used instead of 7 in lines 2630 and 2670, and line 402 could be changed to NYRO = TIME(NRO).

Discount Rate

The discount rate, RATE, is read in as a decimal number in F format. When a zero discount value, 0.0, is read in, it is changed to RATE = .00001 (line 720) for use as a routing flag which bypasses discounting calculations. For output as a percentage, PRATE = RATE x 100 (line 722) is used. When a write statement outputs PRATE, F5.2 format is used which ignores the 1 for the converted zero discount and writes it as 0.00. If a non-zero discount value is used, RATE remains as read in (as low as 0.01%, or RATE = .0001), the discounting calculations are executed, and the proper percentage rate is output as PRATE.

Dose Rate Multiplier

Calculations within AMRAW-B are done in terms of man-rem of dose. AMRAW-A output is in units of milli-rem for local dose and man-rem for nonspecific dose. A multiplier, THO, is used as a conversion factor and is assigned values of .001 and 1.0 for local dose and nonspecific dose, respectively (see lines 1000 and 1020).

Population

Population projections (high and low) are used for local dose calculations in each zone. Nonspecific dose is based upon a total agricultural production implying a nonspecific population. Calculation of damage for nonspecific dose in line 1980 provides for adjustment by including POPH(9) and POPL(9), high and low "populations" for the nonspecific category as designated by subscript 9. These are set equal to 1.0 (see lines 730 and 740) at present.

Input File Containing MAN1

MAN1L and MAN1N from AMRAW-A are processed to MAN1 in file ECONxx for input to AMRAW-B. This can be via disk or tape file. The user is cautioned that JCL for use of COMPRESS must specify disk or tape to be consistent with the input device specification provided for by the user in AMRAW-B.

Modification for Running on Other Systems

AMRAW, written in FORTRAN IV, was developed with implementation on an IBM 360 system. Some changes may be necessary for operation of AMRAW-B on a CDC or other system. However, some of the conditions which require changes in AMRAW-A such as quadruply dimensioned arrays (see Appendix G in Part 1) do not exist in AMRAW-B, which should simplify conversion.

APPENDIX R

AMRAW-B LISTING

The AMRAW-B code consists of a main program only; there are no subprograms. The code has 394 lines including comment statements.

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Appendix R. AMRAW-B Program Listing

```
C***
C***  AMRAW:  ASSESSMENT METHOD FOR RADIOACTIVE WASTE.
C***  A CODE DEVELOPED BY UNIVERSITY OF NEW MEXICO
C***  UNDER EPA CONTRACT #68-01-3256
C***  THIS LISTING IS AMRAW-B, THE ECONOMIC MODEL,MAY 1978.
C***
      IMPLICIT INTEGER*2 (I-N)
      DOUBLE PRECISION NUCNAM(25),HEAD
      DOUBLE PRECISION NUC2(25)
      DATA HEAD/'PV$/GM.'/
      REAL MAN1(50,8),DDP(8),DPY(8),TIME(50),LAMBDA(8)
      REAL POPL(9),POPH(9),DAMAGE(50),PVN(7,25),TDTKH(25)
      REAL TDTKL(25),X(25,50),DTZ(9),SPV(7),TTD(11),THD(50,11)
      REAL DTH(50,25),DTL(50,25),DYRL(50,11),DYRH(50,11),DLD(11)
      DIMENSION IK(25),IG(11),PV2(7,25),SS(7,11),TUDH(11),TUDL(11)
      DIMENSION IFLAGH(8),TITLE(10),SITE(8,5),REG(8), IKK(25)
      DATA LAMBDA/8*0./
      DATA IFLAGH/1,2,3,4,5,6,7,8/
      INTEGER*4 INDEX,POS(2),IN,IP,IS
      DATA POS/'HIGH',' LOW'/
      DEFINE FILE 2(260,400,U,INDEX)
      CALL FSPIE
      IN=5
      IP=6
      IS=1
      NYRD=30
C***
C***    READ # OF TIME PERIODS,DISCOUNT RATE, RISK OF DEATH($),  ***
C***    DOSE BY BODY SITE, POPULATION PROJECTION(LOW&HIGH) FROM AMB
C***    PRINT INPUT DATA
C***
      READ(IN,651)TITLE
  651 FORMAT(10A4)
      READ(IN,1806)RATE
      READ(IN,1806)VOL
      READ(IN,856)NT,MZ,NK,NIHT
      DO 1640 I=1,NIHT
 1640 READ(IN,1651)(SITE(I,J),J=1,5),DPY(I)
      DO 1650 I=1,MZ
 1650 READ(IN,1652)REG(I),POPH(I),POPL(I)
 1651 FORMAT(5A4,F5.0)
 1652 FORMAT(A4,1X,2F10.0)
  652 FORMAT(///5X,10A4)
      WRITE(IP,652)TITLE
      LL=0
      READ(IN,653)NG
      DO 660 I=1,NG
      READ(IN,653)K,(IKK(J),J=1,K)
      IG(I)=K
      DO 665 J=1,K
      L=LL+J
  665 IK(L)=IKK(J)
  660 LL=L
```

Appendix R. Table R-1 continued

```
 653 FCRMAT(3X,25I3)
     MZP1=MZ+1
     DC 2807 I=1,NIHT
2807 DDP(I)=DPY(I)*.26
     IF(RATE.EQ.0.)RATE=0.00001
     PRATE=RATE*100.
     FOPH(9)=1.
     POPL(9)=1.
     WRITE(IP,2806)PRATE,VOL
2806 FCRMAT(/5X,'DISCOUNT RATE =',F5.2,' %'/5X,'COST OF INCREASED '
    *,'LEVEL OF RISK OF DEATH = $',F8.0//33X,
    *'CCST OF EXCESS RISK OF DEATH'/7X,'SITE OR TYPE',8X,
    * 'DEATH /MIL. MAN-REM',4X,'$/MAN-REM'/)
      DO 2601 I=1,NIHT
2601  WRITE(IP,2607)(SITE(I,J),J=1,5),DPY(I),DDP(I)
2607  FORMAT(5X,5A4,1X,2F16.1)
      WRITE(IP,2608)
2608 FCRMAT(//7X,'POPULATION PROJECTIONS'/5X,' ZONE ',5X,
    *'HIGH',6X,'LOW'/)
     DC 2602 I=1,MZ
2602 WRITE(IP,2609)I,REG(I),FOPH(I),POPL(I)
2609 FORMAT(5X,I1,1X,A4,2F10.0)
C***
C***    READ TIME INTERVALS AND NUCLIDE INVENTORY FROM AMIE  ***
C***
     READ(5,806)(TIME(I),I=1,NT)
     DC 650 K=1,NK
     READ(5,808)NUCNAM(K),(X(K,IT),IT=1,7)
 650 READ(5,809)(X(K,IT),IT=8,NT)
C***
C***    READ MAN1 (AMRAW-A OUTPUT) FROM ECONXX   ***
C***    CALCULATE DAMAGES AND STORE ON DISK   ***
C***
     THC=.001
     DC 900 IZ=1,MZP1
     IF(IZ.EQ.9)THO=1.0
     DO 900 K=1,NK
C    WRITE(IP,3806)IZ,K
3806 FCRMAT('1','IZ=',I1,'   K=',I2//)
     DO 901 IT=1,NT
     DAMAGE(IT)=0.0
     READ(IS,806)(MAN1(IT,IH),IH=1,NIHT)
C    WRITE(IP,806)(MAN1(IT,IH),IH=1,NIHT)
 901 CCNTINUE
     DO 902 IT=1,NT
     DO 902 IH=1,NIHT
     IHT=IH
C***
C***    CHECK IF TOTAL BODY DCSE RATE IS TO BE USED  ***
C***
     IF(IFLAGH(IH).NE.IH)IHT=1
 902 DAMAGE(IT)=DAMAGE(IT)+MAN1(IT,IHT)*DDP(IH)*
    1EXP(-LAMBDA(IHT)*TIME(IT))*THO
```

Appendix R. Table R-1 continued

```
      INDEX=10*(K-1)+IZ
  900 WRITE(2'INDEX)(DAMAGE(IT),IT=1,NT)
C***
C***     CALCULATE AND PRINT TABLES ON ZONAL AND TOTAL DAMAGES   ***
C***     (HIGH & LOW POPULATION PROJECTION -- $/YEAR )           ***
C***     TABLE - 1
C***
      WRITE(IP,860)
      NTABLE=1
      WRITE(IP,850)NTABLE,POS(1),(REG(J),J=1,MZ)
      DO 921 IT=1,NT
      DO 921 IR=1,11
      DYRL(IT,IR)=0
  921 DYRH(IT,IR)=0
      DO 906 NTABLE=1,2
      DO 903 IT=1,NT
      DT=0.0
      DT9=0.0
      DO 905 IZ=1,MZP1
  905 DTZ(IZ)=0.0
      DO 904 IZ=1,MZP1
      IF(IT.LE.7)GO TO 903
      DO 904 K=1,NK
      INDEX=10*(K-1)+IZ
      READ(2'INDEX)(DAMAGE(ITE),ITE=1,NT)
      IF(NTABLE.EQ.1)POP=POPH(IZ)
      IF(NTABLE.EQ.2)POP=POPL(IZ)
      DTZ(IZ)=DTZ(IZ)+DAMAGE(IT)*POP
  904 CONTINUE
      DT=DTZ(1)+DTZ(2)+DTZ(3)+DTZ(4)+DTZ(5)+DTZ(6)+DTZ(7)+DTZ(8)
      DT9=DT+DTZ(9)
      IF(NTABLE.EQ.2)GO TO 917
      DO 1501 IZ=1,MZ
      DYRH(IT,IZ)=DTZ(IZ)
 1501 CONTINUE
      DYRH(IT,9)=DT
      DYRH(IT,10)=DTZ(9)
      DYPH(IT,11)=DT9
  917 CONTINUE
      IF(NTABLE.EQ.1)GO TO 903
      DO 1502 IZ=1,MZ
      DYRL(IT,IZ)=DTZ(IZ)
 1502 CONTINUE
      DYRL(IT,9)=DT
      DYRL(IT,10)=DTZ(9)
      DYRL(IT,11)=DT9
  903 WRITE(IP,851)TIME(IT),(DTZ(IZ),IZ=1,MZ),DT,DTZ(9),DT9
      IF(NTABLE.LT.2)WRITE(IP,860)
      NT2=NTABLE+1
      IF(NTABLE.LT.2)WRITE(IP,850)NT2,POS(2),(REG(J),J=1,MZ)
  906 CONTINUE
C***
C***     $ DAMAGES BY NUCLIDE AND BY TIME PERIOD    ***
```

Appendix R. Table R-1 continued

```
C***     SET ITB3 TO 1 TO PRINT,TO 0 TO SUPPRESS PRINT. ***
C***     TABLE - 2
C***
      ITB3=0
      DC 920 IT=1,NT
      DC 920 K=1,NK
      DTL(IT,K)=0
  920 DTH(IT,K)=0
      DC 907 IT=1,NT
      IF(IT.LE.7)GO TO 916
      IF(ITB3.EQ.1)WRITE(IP,860)
      IF(ITB3.EQ.1)WRITE(IP,861)IT,TIME(IT)
      IF(ITB3.EQ.1)WRITE(IP,853)
  916 CCNTINUE
      DC 915 K=1,NK
      DO 908 I=1,9
  908 DTZ(I)=0.0
      IF(IT.LE.7)GO TO 907
      DC 909 IZ=1,MZ
      INDEX=10*(K-1)+IZ
      READ(2'INDEX)(DAMAGE(ITE),ITE=1,NT)
      DTZ(1)=DTZ(1)+DAMAGE(IT)*POPH(IZ)
  909 DTZ(2)=DTZ(2)+DAMAGE(IT)*POPL(IZ)
      INDEX=10*(K-1)+9
      READ(2'INDEX)(DAMAGE(ITE),ITE=1,NT)
      DTZ(3)=DTZ(3)+DAMAGE(IT)*(POPL(9)+POPH(9))/2.
      DTZ(4)=DTZ(1)+DTZ(3)
      DTZ(5)=DTZ(2)+DTZ(3)
      DTH(IT,K)=DTZ(4)
      DTL(IT,K)=DTZ(5)
      IF(ITB3.EQ.1)WRITE(IP,854)NUCNAM(K),(DTZ(I),I=1,5)
  915 CCNTINUE
  907 CCNTINUE
C***
C***    DISCOUNTED PRESENT VALUE FOR HIGH & LOW POPULATION BY NUCLIDE *
C***    TABLE - 3
C***
      WRITE(IP,2222)PRATE
 2222 FCRMAT('1',5X,'TABLE 3 : DISCOUNTED PRESENT VALUES ( $ )'/
     * 16X,'DISCOUNT RATE =',F5.2,' %'//
     *14X,'HIGH POPULATION',9X,'LOW POPULATION'/
     *1X,'NUCLIDE ',2(3X,'DISCOUNTED',4X,'PV $/GM')/)
      M1=2
      DC 912 II=1,2
      DC 911 K=1,NK
  911 PVN(1,K)=0.0
      DO 913 K=1,NK
      DC 913 IT=2,NT
      IF(II.EQ.1)TD=DTH(IT,K)
      IF(II.EQ.2)TD=DTL(IT,K)
      Z1=TIME(IT-1)
      Z2=TIME(IT)
      IF(RATE.EQ.0.00001)GO TO 914
```

Appendix R. Table R-1 continued

```
      IF(RATE*Z1.GT.15.)GO TO 913
      IF(RATE*Z2.GT.15.)GO TO 913
      PVN(1,K)=PVN(1,K)+TD*((1/RATE)*(EXP(RATE
     **KYRD))*((EXP(-RATE*Z1))-(EXP(-RATE*Z2))))
      IF(RATE.NE.0.00001)GO TC 913
  914 PVN(1,K)=PVN(1,K)+TD*(Z2-Z1)
  913 CCNTINUE
        DO 10 K=1,NK
        ID=IK(K)
        NUC2(K)=NUCNAM(ID)
   10   PV2(1,K)=PVN(1,ID)
        L2=0
        DO 20 J=1,NG
        ID=IG(J)
        L1=L2+1
        L2=L2+ID
        SS(1,J)=0
        DO 20 K=L1,L2
   20   SS(1,J)=SS(1,J)+PV2(1,K)
      L2=0
      DC 1001 J=1,NG
      ID=IG(J)
      L1=L2+1
      L2=L2+ID
      DO 1002 K=L1,L2
 1002 PV2(M1,K)=PV2(1,K)
 1001 SS(M1,J)=SS(1,J)
      SPV(1)=0
      DO 935 K=1,NK
  935 SPV(1)=SPV(1)+PVN(1,K)
      SPV(M1)=SPV(1)
      M1=M1+1
C***
C***    DISCOUNTED PRESENT VALUE PER GRAM OF INITIAL WASTE MIX   ***
C***    FOR HIGH & LOW POPULATION                                ***
C***
      DO 910 K=1,NK
  910 PVN(1,K)=PVN(1,K)/X(K,7)
        DO 30 K=1,NK
        ID=IK(K)
        NUC2(K)=NUCNAM(ID)
        PVN(2,K)=X(ID,7)
   30   PV2(1,K)=PVN(1,ID)
        L2=0
        DO 40 J=1,NG
        ID=IG(J)
        L1=L2+1
        L2=L2+ID
        SS(1,J)=0
        DC 40 K=L1,L2
   40   SS(1,J)=SS(1,J)+PVN(2,K)
      M11=M1-1
      L2=0
```

Appendix R. Table R-1 continued

```
      DC 1003 J=1,NG
      ID=IG(J)
      L1=L2+1
      L2=L2+ID
      DO 1004 K=L1,L2
 1004 PV2(M1,K)=PV2(1,K)
 1003 SS(M1,J)=SS(M1,J)/SS(1,J)
      SPV(1)=0
      DC 2935 K=1,NK
 2935 SPV(1)=SPV(1)+PVN(2,K)
      SPV(M1)=SPV(M1)/SPV(1)
       M1=M1+1
  912 CCNTINUE
      L2=0
      DO 1014 J=1,NG
      IC=IG(J)
      L1=L2+1
      L2=L2+ID
      DO 1013 K=L1,L2
 1013 WRITE(IP,2855)NUC2(K),PV2(2,K),PV2(4,K)
 2855 FCRMAT((1X,A8,1X,1PE12.2,12X,1PE12.2))
 1014 WRITE(IP,1967)(SS(L,J),L=2,5)
 1015 WRITE(IP,967)(SPV(L),L=2,5)
C***
C***    # OF DEATHS PER TIME INTERVAL FOR HIGH & LOW POPULATION   ***
C***    TABLE - 4
C***
      DC 933 I=1,2
      PL=0
      IF(I.EQ.1)WRITE(IP,919)I,POS(1)
      IF(I.EQ.2)WRITE(IP,919)I,POS(2)
      WRITE(IP,918)VOL,(REG(J),J=1,MZ)
      DO 969 IR=1,11
      DLD(IR)=0
  969 TTD(IR)=0
      DC 970 IT=1,NT
      DC 970 IR=1,11
  970 THD(IT,IR)=0
      DC 932 IT=1,NT
      DO 931 IR=1,11
      IF(I.EQ.1)DV=DVRH(IT,IR)
      IF(I.EQ.2)DV=DVRL(IT,IR)
      IF(IT.EQ.1.)GO TO 989
      PL=TIME(IT)-TIME(IT-1)
  989 CCNTINUE
      DLD(IR)=(DV/VOL)*(PL)
  931 THD(IT,IR)=DLD(IR)
  932 WRITE(IP,851)TIME(IT),(DLD(IR),IR=1,11)
      DO 955 IR=1,11
      TTC(IR)=0
      DC 955 IT=1,NT
  955 TTD(IR)=TTD(IR)+THD(IT,IR)
  934 WRITE(IP,968)(TTD(IR),IR=1,11)
```

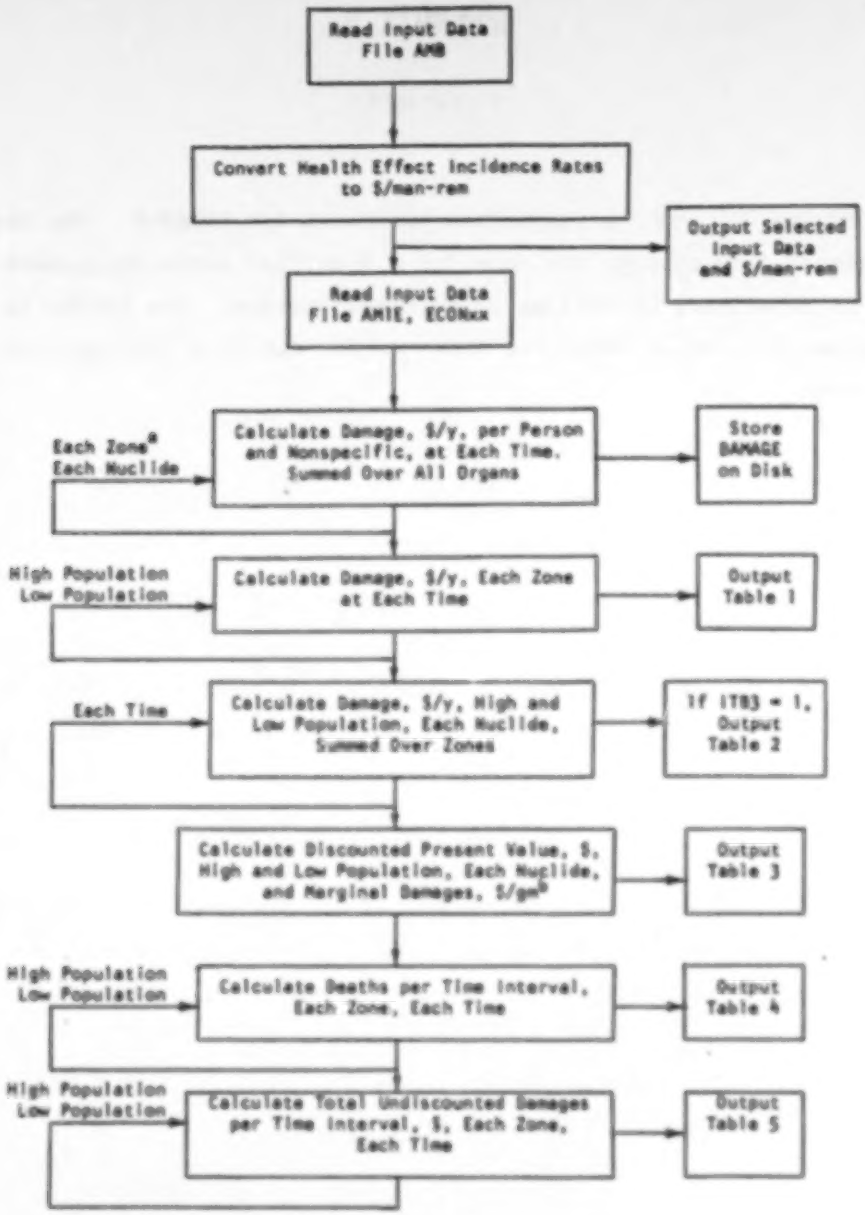
Appendix R. Table R-1 continued

```
  933 CCNTINUE
C***
C***    TOTAL UNDISCOUNTED DAMAGES FOR EACH ZONE & FOR EACH TIME    ***
C***    INTERVAL  --  FOR HIGH & LOW POPULATION                     ***
C***    TABLE - 5
C***
      PL=0
      DC 1600 IR=1,11
      TLDH(IR)=0.
      TUDL(IR)=0.
      DC 1600 IT=2,NT
      PL=TIME(IT)-TIME(IT-1)
      DYRH(IT,IR)=DYRH(IT,IR)*PL
      TLDH(IR)=TUDH(IR)+DYRH(IT,IR)
      DYRL(IT,IR)=DYRL(IT,IR)*PL
 1600 TLDL(IR)=TUDL(IR)+DYRL(IT,IR)
      K1=1
      K2=2
      WRITE(IP,957)K1,POS(1),(REG(J),J=1,MZ)
      DO 1601 IT=1,NT
 1601 WRITE(IP,851)TIME(IT),(DYRH(IT,IR),IR=1,11)
      WRITE(IP,968)(TUDH(IR),IR=1,11)
      WRITE(IP,957)K2,POS(2),(REG(J),J=1,MZ)
      DC 1602 IT=1,NT
 1602 WRITE(IP,851)TIME(IT),(DYRL(IT,IR),IR=1,11)
      WRITE(IP,968)(TUDL(IR),IR=1,11)
      STOP
  806 FCRMAT(1P8E10.2)
 1806 FCRMAT(15X,F10.0)
 1807 FCRMAT(8F5.0)
  808 FCRMAT(A8,2X,7E10.2)
  809 FCRMAT(10X,7E10.2)
  850 FCRMAT(T6,20X,'TABLE 1 - ',I1,' : ',
     *'ZCNAL AND TOTAL DAMAGES FOR ',A4,' POP. PROJECTION ($/YR)'
     *//,6X,' TIME',2X,8(A4,6X),'TOT.ZONE',2X,'NON-SPEC',
     *2X,'TTOTAL')
  851 FORMAT(F11.0,1P11E10.2)
  853 FCRMAT(2X,'NUCLIDE',5X,'HIGH POP',4X,'LOW POP',5X,'NON-SPEC'
     *,4X,'TOT-HIGH',4X,'TOT-LOW')
  854 FCRMAT(1X,A8,1X,1P5E12.2)
  857 FCRMAT('1',A8,' POPULATION SCENARIO - DISCOUNTED PRESENT ',
     *'VALUE ($)'//'  NUCLIDE  INTEREST RATES-',F6.3/)
  855 FCRMAT((1X,A8,1X,1P7E12.2))
  856 FCPMAT(20X,I5)
  860 FORMAT('1')
  861 FCRMAT(10X,'TABLE 2 - ',I2,' : ','TIME PERIOD=',F11.0//)
  918 FCRMAT(33X,'NUMBER OF CEATHS PER TIME INTERVAL,($',F7.0,')'
     *//,6X,' TIME',2X,8(A4,6X),'TOT.ZONE',2X,'NON-SPEC',
     *2X,'TTOTAL'/)
  950 FORMAT(18X,'0%',10X,'1%',10X,'2%',10X,'3%',10X,'4%',10X,
     *'5%',10X,'6%'/)
  919 FORMAT('1',T37,'TABLE 4 - ',I1,' : ',A4,' POPULATION SCENARIO')
  967 FORMAT(1X,'TOTAL    ',1X,1P7E12.2)
 1967 FCRMAT(1X,' SUB TOT',1X,1P7E12.2)
  968 FCRMAT(1X,'TOTAL',5X,1P11E10.2)
  957 FCRMAT('1',6X,'TABLE 5 - ',I1,' : ','TOTAL UNDISCOUNTED DAMAGES '
     *,'FOR EACH ZONE',1X,'FCR EACH TIME INTERVAL -'
     *,1X,A4,1X,'POPULATION'//,6X,' TIME',2X,
     *8(A4,6X),'TOT.ZONE',2X,'NON-SPEC',
     *2X,'TTOTAL'/)
      END
```

APPENDIX S

FLOWCHART

Figure S-1 shows a simplified flowchart for AMRAW-B. The chart represents flow through the code for a specified waste management phase, such as repository operations or terminal storage. The reader is referred to Volume III, which describes AMRAW-B, for detailed descriptions of each step.


Read Input Data
File AMB
Convert Health Effect Incidence Rates
to $/man-rem
Output Selected
Input Data
and $/man-rem
Read Input Data
File AMIE, ECONxx
Each Zone[a]
Each Nuclide
Calculate Damage, $/y, per Person
and Nonspecific, at Each Time,
Summed Over All Organs
Store
DAMAGE
on Disk
High Population
Low Population
Calculate Damage, $/y, Each Zone
at Each Time
Output
Table 1
Each Time
Calculate Damage, $/y, High and
Low Population, Each Nuclide,
Summed Over Zones
If ITB3 = 1,
Output
Table 2
Calculate Discounted Present Value, $,
High and Low Population, Each Nuclide,
and Marginal Damages, $/gm[b]
Output
Table 3
High Population
Low Population
Calculate Deaths per Time Interval,
Each Zone, Each Time
Output
Table 4
High Population
Low Population
Calculate Total Undiscounted Damages
per Time Interval, $, Each Zone,
Each Time
Output
Table 5

[a] The term "Each Zone" also indicates the sums of all zones, nonspecific, and total of zones and nonspecific.

[b] Marginal damages are based upon inventory of each decay chain at beginning of e.g. terminal storage.

Figure S-1. AMRAW-B simplified flowchart.

APPENDIX T

AUXILIARY PROGRAM

An auxiliary program COMPRESS, is used to process dose rate output from AMRAW-A for use as input to AMRAW-B via the file ECONxx. All of the AMRAW-A output tables in Section 3 (Local Dose to Individual) and Section 4 (Nonspecific Dose to Population) comprise the major input to AMRAW-B (Economic Model). COMPRESS, written in PL-1 and Fortran IV language, finds these tables in the full output stored on tape, strips off the headings and left hand column of time, and outputs a continuous "compressed" file in a form ready to be read by AMRAW-B. Appendix P includes samples of AMRAW-A output and the COMPRESS output file.

The COMPRESS output file consists of the calculated value of dose rates (each line is for sequence of organs calculated for a specific time), for each nuclide in the first geographic zone, followed by the same sequence in each of the other zones in turn and finally, by the nonspecific category. The program may be used separately to produce AMRAW-B input files ECONxx from AMRAW-A output (xx identifies the case number), or it may be joined to AMRAW-B to process data directly. Table T-1 is a listing of COMPRESS, including JCL, as run on the IBM360/67 computer at UNM. The first execution step employs PL-1 and the second step employs Fortran IV. It is necessary to specify, in the JCL cards, the name of the tape and label number storing the AMRAW-A output (see line 390), and the name and label for the output file tape or the DSN for the output disk if used instead of tape (see lines 125 and 690).

Table T-1. Listing of COMPRESS

```
//A         JOB (BAB411,LGK,500,20),'HENRY NG'
// REGION=256K
/*SETUP          9NLHN1619,BD5  2314
//DELETE   EXEC PGM=IEHPROGM
//SYSPRINT   DD SYSOUT=A
//SCT        DD UNIT=2314,VOL=SER=BD5,DISP=SHR
//SYSIN      DD *
      SCRATCH DSNAME=ECON35,VOL=2314=BD5
/*
//SQUEEZ EXEC LPL1FCG,CPARM='ST,NEST,NOL',P2=DUMMY
//PL1.SYSIN DD *
 /*   FIND EXTRANEOUS MATERIAL AND DELETE IT */
 EXCESS: PROC OPTIONS(MAIN);
 DCL CRUNCH FILE RECORD OUTPUT;
 DCL EXTRA FILE RECORD INPUT;
 DCL DATA CHAR(133) VARYING;
 DCL SUBSTR BUILTIN;
 ON ENDFILE (EXTRA) GO TO FINISH;
              OPEN FILE(CRUNCH);
              OPEN FILE(EXTRA);
 /* FIND 'SECTION  3' IN OUTPUT */
     AGAIN: READ FILE(EXTRA) INTO (DATA);
              IF SUBSTR(DATA,61,10)¬='SECTION  3' THEN GO TO AGAIN;
 PUT SKIP LIST(DATA);
 /* FIND 'TIME' IN OUTPUT */
     TIMER: READ FILE(EXTRA) INTO (DATA);
              IF SUBSTR(DATA,7,4)¬='TIME' THEN GO TO TIMER;
              DO IN=1 TO 50;
                 READ FILE(EXTRA) INTO (DATA);
                 WRITE FILE(CRUNCH) FROM (DATA);
              END;
              GO TO TIMER;
    FINISH: CLOSE FILE(CRUNCH);
              CLOSE FILE(EXTRA);
 END EXCESS;
//GO.EXTRA DD UNIT=TAPE9,VOL=SER=HN1619,DSN=EPAJOB,LABEL=(5,BL),
// DISP=(OLD,PASS)
//GO.CRUNCH DD UNIT=SYSW,DSN=&&SQUEEZE,DISP=(NEW,PASS),
// DCB=(RECFM=FB,LRECL=133,BLKSIZE=6650),SPACE=(CYL,(1,1),RLSE)
//REVAMP EXEC LFORTGCG,LPARM='SIZE=225K'
//FORT.SYSIN DD *
      DIMENSION RDATA(50,8)
      DO 10 IZ=1,9
      DO 10 NUC=1,25
      DO 10 IT=1,50
      READ(1,100)(RDATA(IT,IORGN),IORGN=1,8)
      WRITE(2,200)(RDATA(IT,IORGN),IORGN=1,8)
   10 CONTINUE
  100 FORMAT(11X,1P8E10.2)
  200 FORMAT(1P8E10.2)
      ENDFILE 2
      REWIND 2
      STOP
      END
//GO.FT01F001 DD UNIT=SYSW,DSN=&&SQUEEZE,DISP=(OLD,DELETE)
//GO.FT02F001 DD UNIT=2314,VOL=SER=BD5,DSN=ECON35,DISP=(NEW,KEEP),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=7200),SPACE=(CYL,(5,2),RLSE)
//
/*
```